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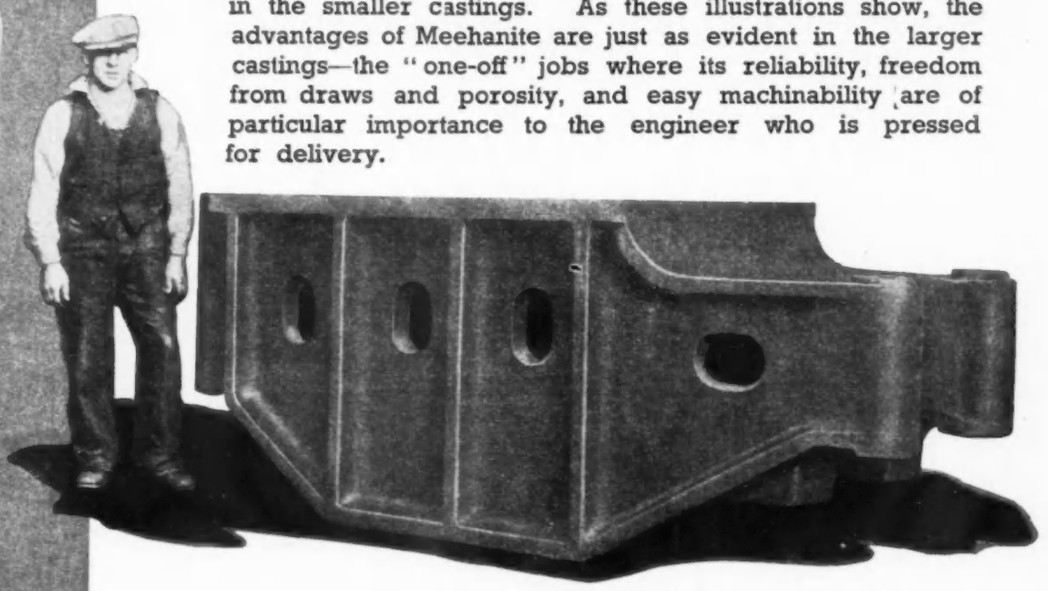

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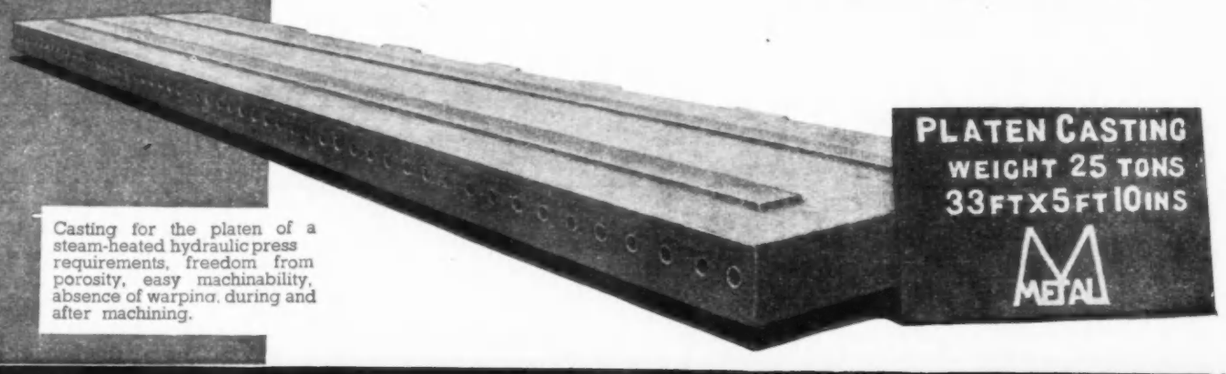

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GENERATING FLAT SURFACES.

By E. V. WAIT, B.Sc., B.E.

IT would be impossible for precision machinery of any kind to be built if no means already existed for producing flat surfaces. The best known method of originating a flat surface is that practised by Whitworth. Particular interest centres around Whitworth's three-plate method, both because no machine-made tools or instruments are necessary, and because plates of the highest degree of accuracy can be generated. Speaking generally, however, engineers are under a mistaken impression that this process is much simpler in operation than it actually is. This has been due to a deficiency in the published literature, which it is the purpose of this article to make good.

Fig. 1.

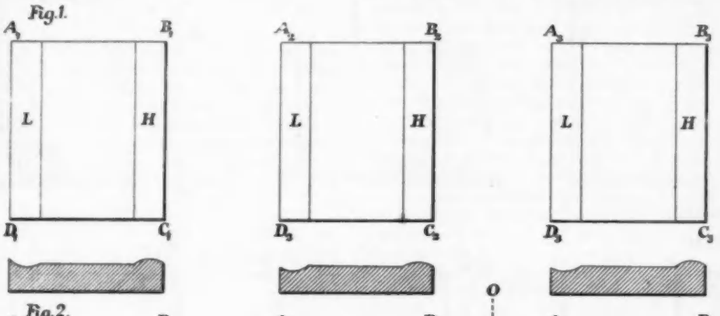


Fig. 2.

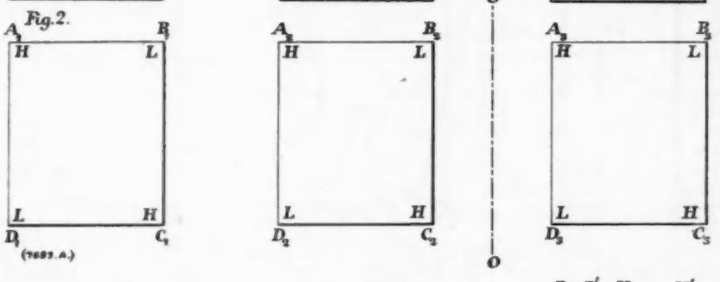


Fig. 3.

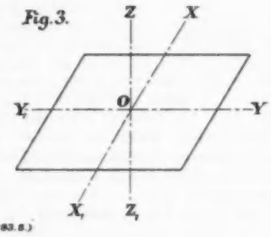
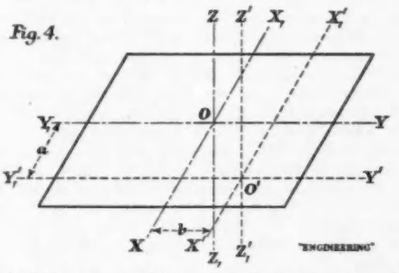


Fig. 4.



In Whitworth's method, the top surfaces of three metal plates are worked together systematically in pairs until each makes contact over its whole surface when placed against either of the other two. The areas of contact between two plates can be shown up by covering the plates with marking compound, placing them together, and rubbing them against each other just sufficiently to mark the areas of contact. Metal can be removed from the high spots by filing or scraping or, alternatively, the plates can be lapped together until the areas of contact are widely distributed over the whole of the plates. In scraping a pair of plates to fit each other, it is not practicable to obtain contact over their whole surfaces, but it is usually considered that, if the process of working together of the plates in pairs were continued until each plate could be placed so as to make contact over its whole surface with the other two plates, then all three plates would necessarily be flat. This, however, would not be the case, unless each pair of plates fitted together perfectly in a large number of different positions. This will be shown by a number of instances.

Consider first that three surface plates had originally a general shape, as shown in Fig. 1. In this and other illustrations, L indicates a low area and H a high area. The plate $A_1\ B_1\ C_1\ D_1$ can be turned upside down and placed over the plate $A_2\ B_2\ C_2\ D_2$ and make perfect contact with it in one position only, namely, corner A_1 above corner B_2, corner B_1 above corner A_2, corner C_1 above corner D_2, and corner D_1 above corner C_2. Similarly, the plate $A_2\ B_2\ C_2\ D_2$ will fit over the plate $A_3\ B_3\ C_3\ D_3$ in one position only, and also the plate $A_3\ B_3\ C_3\ D_3$ will fit over the plate $A_1\ B_1\ C_1\ D_1$ in one position only. If, however, the toolmaker were to turn the first pair of plates to the position in which corner A_1 is above corner D_2, corner B_1 is above corner C_2, corner C_1 is above corner B_2, and corner D_1 is above corner A_2, the high spots on each plate would be revealed, and could be removed by scraping or filing. It would then be possible to pick up the low spots by lack of contact.

Consider next the case of three surface plates which, after machining, had shapes as indicated in Fig. 2. In placing the surface plate $A_1\ B_1\ C_1\ D_1$ upside down over the surface plate $A_2\ B_2\ C_2\ D_2$, two positions are most likely to be chosen. In both positions, the long axes of the plates are superimposed and the plates completely cover each other. In the first position, corner A_1 (high) above corner B_2 (low), corner B_1 (low) above corner A_2 (high), corner D_1 (low) above corner C_2 (high), and corner C_1 (high) above corner D_2 (low). In the second position, corner A_1 (high) above corner D_2 (low), corner D_1 (low) above corner A_2 (high), corner C_1 (high) above corner B_2 (low), and corner B_1 (low) above corner C_2 (high) and it will be seen that perfect contact is possible in both positions. Similarly, it can be shown that the plate $A_2\ B_2\ C_2\ D_2$ can make perfect contact with the plate $A_3\ B_3\ C_3\ D_3$ and, also, that the plate $A_3\ B_3\ C_3\ D_3$ can make perfect contact with the plate $A_1\ B_1\ C_1\ D_1$ in two positions.

It frequently happens that in the preliminary machining of a surface plate it is mounted on the planer bed in such a way that rocking takes place about two opposite corners. A surface is produced with a pair of opposite corners high and a pair low. Again, a slight twist in the plate, introduced by springing after the clamps holding it to the machine bed have been removed, will give the same effect. Twisting may also occur during the ageing process. If, then, the two other plates are scraped to match this plate, all three plates will be similar to those in Fig. 2. Subsequent pairing and scraping of the plates to match in the two positions described above will make the surfaces of all three plates more similar, but will not reduce their tendency to have two high and two low corners.

The equation to a surface uniformly twisted about the X axis is $z = y \tan K x$, where z is the height of any point on its surface above its mean plane XY, and K is a parameter determining the degree of twist. The amount of twisting likely to occur in a machined surface plate is small, and $K x$, measured in radians, is not likely to exceed 0·0001. Hence the machined surface will often be approximately equal to the hyperbolic paraboloid :—

$$z = K x y. \quad . \quad . \quad . \quad (1)$$

The latter surface is symmetrical when referred to the axes of X and Y, and it is particularly liable to be produced instead of a flat surface in using the three-plate method. This will be shown by proving by co-ordinate geometry some simple properties of the hyperbolic paraboloid, referring to Fig. 3. If we rotate the hyperbolic paraboloid P Q through 180 deg. about the axis $X X_1$, (1) becomes

$$-z = K x(-y) \text{ or } z = K x y \quad . \quad . \quad (2)$$

as before. Similarly, if we rotate the surface P Q through 180 deg. about the axis $Y Y_1$, its equation (1) remains unchanged. The significance of this is that a twisted surface can be turned upside down and placed on top of an exactly similar surface in two positions displaced from each other by 180 deg., so that contact takes place at every point on the surface. This has already been shown diagrammatically in Fig. 2, which, however, applies to many other types of surface.

The equation to the surface $z = K x y$ referred to a new set of axes $X' X_1'$, $Y' Y_1'$, $Z' Z_1'$, displaced by amounts a parallel to O X, and b parallel to O Y, Fig. 4, is

$$\begin{aligned} z &= K(x' + a)(y' + b) \\ &= K x' y' + K b x' + K a y' + K a b. \quad (3) \end{aligned}$$

In even the most badly twisted surface plates K will be very small. For instance, a plate 3 ft. square with a pair of diagonally opposite corners 0·002 in. above the mean plane, and the other pair 0·002 in. below the mean plane, would have

$$K = \frac{z}{x y},$$

i.e.

$$K = \frac{0{\cdot}002 \text{ in.}}{18 \text{ in} \times 18 \text{ in.}} = 6{\cdot}2 \times 10^{-6} \text{ per in.}$$

If, instead of the axes $X' X_1'$, $Y' Y_1'$, $Z' Z_1'$, we had used a new set $X'' X_1''$, $Y'' Y_1''$, $Z'' Z_1''$, passing through the first origin and obtained by rotating the axes through an angle θ about O Y and an angle $-\omega$ about $O'' X''$, we should have obtained a surface

$$z'' = K x'' y'' + x'' \tan \theta + y'' \tan \omega, \quad (4)$$

provided K is very small.

If, finally, we used another set of axes $X''' X_1'''$, $Y''' Y_1'''$, $Z''' Z_1'''$, obtained by moving the axes $X'' X_1''$, $Y'' Y_1''$, $Z'' Z_1''$, by an amount

$$\frac{\tan \theta \tan \omega}{K}$$

parallel to the $Z'' Z_1''$ axis, we should have obtained an equation

$$z''' = K x''' y''' + x''' \tan \theta + y''' \tan \omega + \frac{\tan \theta \tan \omega}{K} \quad . \quad . \quad (5)$$

Equation (5) will be identical with equation (3) provided that

$$\tan \theta = K b \text{ and } \tan \omega = K a.$$

Equations (1), (3) and (5) are sufficient to prove a peculiar property of the slightly but uniformly twisted surface, that it can be placed upside down on top of a surface of identical shape and for all practical purposes make perfect contact with it in any position at all, so long as there is either no rotation, or 180 deg. rotation, of one surface relatively to the other in the plane of both. Two such

GENERATING FLAT SURFACES.

Fig. 5.

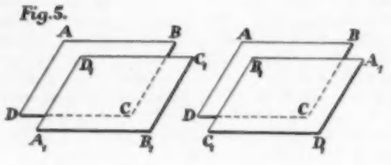


Fig. 6.

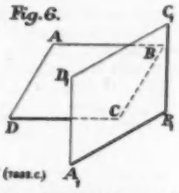
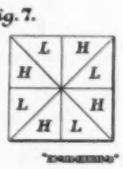


Fig. 7.



surfaces A B C D and A_1 B_1 C_1 D_1 will fit perfectly together in any positions, such as those shown in Fig. 5, and will not fit in any position such as that shown in Fig. 6.

We have shown, therefore, that in generating flat surfaces by matching three plates together in pairs, it is necessary for the plates to match in more than one position. To avoid twist in the plates, it is necessary for them to match in several positions varying from one another by angular rotation of the top plate. When this matching has been effected, it is still not certain that the plates are flat. Supposing that we had three polygonal plates of n sides and that we matched each pair of them together in the n ways in which they would completely cover each other, then a type of distortion illustrated in Fig. 7 for square plates ($n = 4$) could exist unnoticed. The distortion would be discovered, however, if we were to turn the plates to a position where the sides did not cover each other, either by rotating the top plate through an angle different from $\frac{360}{n}$ deg., or by giving it some translatory motion, in addition to the rotation already given to eliminate the possibility of twist.

We have now to consider the best means of preventing the various types of distortion described above. There are two methods of attack:—(1) A process could be chosen for removing the metal to obtain matching, so that none of the types of distortion described above could be produced; and (2) a system might be devised whereby the pairs of plates were checked in a sufficient number of positions to ensure that distortion of any kind would be revealed. Method (1) is only applicable to lapping. If the lapping is carried out by hand, some rotation of the upper plate, in addition to the usual cycloidal translatory motion, would be necessary to eliminate any possibility of twist developing in the surfaces. If the lapping is carried out by rotating the plates together in a machine, there is a possibility that wavy distortion of the type shown in Fig. 7 may occur on all plates owing to a uniform slight vibration of the spindle or bedplate. This possibility can be eliminated by arranging for translatory, as well as rotary, movement of the plates. Method (2) is applicable to both lapped plates and scraped plates.

The most common shape for surface plates is rectangular. It is suggested that three rectangular surface plates should be required to fit together in pairs in each of the positions shown in Fig. 8. After matching in positions (*a*) and (*b*), distortion of the type shown in Fig. 1 should be eliminated. In positions (*c*), (*d*), (*e*) and (*f*), the top plate is rotated through 90 deg. and the matching should eliminate twist, while the translatory motion of the centre of the top plate in moving through the positions (*b*), (*e*), (*d*), (*e*) and (*f*) should eliminate any distortion of the type shown in Fig. 7. Less trouble is likely to be experienced in generating flat surfaces on round and square plates since rotation of these plates is likely to take place unintentionally. Square plates might, of course, develop a wavy distortion of the type shown in Fig. 7, but this is less likely to happen, and the

Fig. 8.

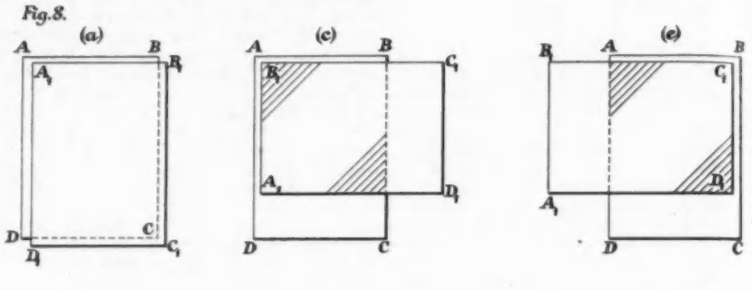


Fig. 9.

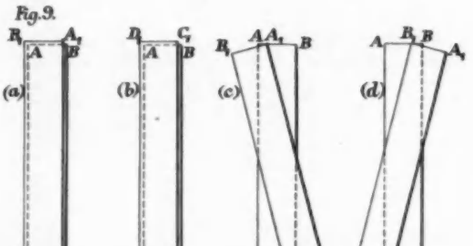
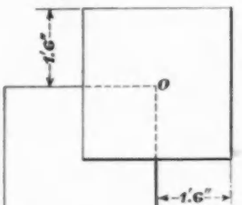


Fig. 10.



results would be less serious than with the twisted type of distortion shown in Fig. 2. The possibility of wavy distortion could be eliminated by removing metal where this is called for after fitting together in the manner described in connection with Fig. 7.

Very long rectangular plates, such as are used for testing lathe beds, are more difficult to deal with. Crossing them so that the long axes are at right angles does not leave a sufficient area of possible contact. It is suggested that they might be checked in the positions shown in Fig. 9, and that the possibility of distortion of the type shown in Fig. 7 should be reduced by taking care not to match regularly in positions, Fig. 9, (*c*) and (*d*), with exactly the same angular displacement of the top plate.

In most descriptions of the "three plate" method of generating flat surfaces, it is first suggested that each pair of plates can be made to fit by lapping them together. (This removes an approximately equal amount of metal from each plate and makes the plates fit each other in a large number of relative positions.) The prevalent form of distortion, after thoroughly lapping a pair of plates together, is for one of them to have a concave and the other a convex spherical surface. After each plate has been lapped at least once against another plate, either concave or convex spherical distortion will exist on each plate. It is easy to show that this spherical distortion will be quickly eliminated by lapping together in pairs. (In practice, however, flat surfaces are more often produced by scraping than by lapping, because scraping is less laborious and produces a surface which is more suitable for surface plates, as slip gauges will not wring on to it.) It is then stated, in a rather vague fashion, that, instead of lapping the plates, metal can be removed by scraping or filing. This is true, but considerably more care must then be taken in checking the flat surfaces against each other.

One writer, however, describes the process in precise manner, and the following is quoted from his work*:—"It is possible to produce an accurate surface plate" because "flat surfaces are self-checking and the method employed is based on a fundamental principle known as the 'symmetrical distribution of errors.' In order to originate a surface plate, it is necessary to have three suitable castings . . . These castings are numbered 1, 2 and 3. . . . Marking compound is then applied to plates Nos. 1 and 2, and each is roughly scraped until a reasonably good bearing distribution is obtained, all rocking being eliminated. No. 3 plate is now roughly fitted to No. 1. This must be done by scraping No. 3 plate only, no metal being removed from plate No. 1. As a result, plate No. 3 will be an approximate duplicate of No. 2. Neither will be flat, but the errors in each will be approximately the same and the reverse of those in plate No. 1. . . . On applying plate No. 2 to No. 3, the errors which were previously masked by the reverse deficiencies of No. 1 are now duplicated and accentuated." This writer has been sufficiently precise to commit himself to an error which is implicit in the more vague descriptions of others.

Referring again to Fig. 2, if the plates A_2 B_2 C_2 D_2 and A_3 B_3 C_3 D_3 have been scraped against the plate A_1 B_1 C_1 D_1, the errors in A_2 B_2 C_2 D_2 and A_3 B_3 C_3 D_3 will be approximately the same, but they will not be the reverse of those in A_1 B_1 C_1 D_1 after all three plates have been turned with their faces upwards. On applying the plate A_2 B_2 C_2 D_2 to the plate A_3 B_3 C_3 D_3, the errors which were previously masked by the deficiencies of A_1 B_1 C_1 D_1 are now not "duplicated and accentuated," but masked by the deficiencies of A_3 B_3 C_3 D_3. In other words, the errors in the surface plates A_2 B_2 C_2 D_2 and

* *Tool Room Practice*, Part 1. "Plane Surfaces and Straight Edges," *Machinery's Yellow Back Series*. No. 13, page 20.

A_1 B_2 C_3 D_4 are similar, but not symmetrically distributed about the chain dotted line OO, Fig. 2, and, if the paper were folded about this line, it would not bring high spots on A_2 B_3 C_4 D_1 above high spots on A_1 B_2 C_3 D_4.

Articles on the generating of flat surfaces are not as numerous as the importance and interest of the subject would seem to demand, but those mentioned below* may be referred to. Articles dealing with lapping frequently contain a paragraph or two on generating flat surfaces on the master lapping plates, and a list of these will be found in *Gauges and Fine Measurements*, by F. H. Rolt, vol. 1, page 94.

The author desires to thank Mr. J. H. A. Scarr, of the Chief Mechanical Engineeer's Branch of the New South Wales Government Railways, for bringing to his notice the important property of the uniformly twisted surface illustrated in Figs. 5 and 6 and for assistance in preparing this article.

APPENDIX.

In the early part of the above article use has been made of two approximate relationships. While most readers will readily admit that the error involved is negligible, it may be of interest to show by means of a table the actual amounts involved in a particular case. For two uniformly twisted plates 3 ft. square, the degree of twist is shown in col. 1 of the accompanying table by the amount that

TABLE I.

Diagonal Corners above or below mean plane.	K in. $^{-1}$.	K x y − y (tan K x radians) for corner points.	Maximum Gap between Plates placed as in Fig. 10 : both Hyperbolic Paraboloids.
0·002 in. ..	$6 \cdot 2 \cdot 10^{-4}$	Less than 10^{-13} in.	13×10^{-11} in.
0·02 ,, ..	$6 \cdot 2 \cdot 10^{-3}$	,, 10^{-9} ,,	13×10^{-8} ,,
0·2 ,, ..	$6 \cdot 2 \cdot 10^{-4}$	,, 10^{-5} ,,	13×10^{-6} ,,
2·0 ,, ..	$6 \cdot 2 \cdot 10^{-3}$	,, 10^{-2} ,,	13×10^{-2} ,,

diagonally opposite corners are above or below the mean plane. In col. 2 is given the value of K required to satisfy the equation $z = y \tan \mathrm{K}\,x$. In col. 3 is given the difference between K x y and y tan K x for the corner points. This is the maximum error introduced by treating the uniformly twisted surface as a hyperbolic paraboloid. In col. 4 is given the maximum gap between the two plates when placed as shown in Fig. 10 with the surfaces tangential at O. Col. 4 gives the difference between z' and z''' introduced by the approximate nature of equation (4). Its value is given by the equation

$$z''' - z' = \tfrac{1}{8}\,\mathrm{K}^3\,a\,b\,(x'''^2 + y'''^2) + \mathrm{K}^3 a\,x'''^2 y''' + \mathrm{K}^3 b\,x''' y'''^2 + \mathrm{K}^5 (a^2 + b^2)\,x''' y''' + \text{terms containing } \mathrm{K}^5 \quad . \quad (6)$$

where a and b are the distances that the top surface plate is moved parallel to the axes of X and Y from its central position above the bottom plate. The derivation of equation (6) is lengthy and will not be given here.

GENERATION OF ELECTRICITY IN SOUTH AFRICA.—The annual report of the South African Electricity Supply Commission shows that 4,176,074,675 units were generated during 1940, an increase of 496,460,000 units over the total for 1939.

CONCRETE RAILWAY SLEEPERS.—A practice reminiscent of the stone blocks used as sleepers on some of the early railways is being revived by the Great Western Railway Company for sidings, goods loops and branch lines where high speeds are not attained. The object is, of course, to conserve the supplies of normal timber sleepers. Under each chair is placed a rectangular concrete block reinforced by a cage of round steel bar and weighing 166 lb. The chairs are secured to the blocks by a pair of bolts with large square washers on the underside, an elm bearing pad ½ in. thick being inserted between the chair and block. The gauge of the rails is maintained by a steel bar of angle section secured at each end by the inner chair bolts, the bars being normally placed between alternate pairs of sleepers.

* "Originating a Surface Plate," *Machinery's Encyclopædia*, vol. vi, page 128 ; *Gauges and Fine Measurements*, by F. H. Rolt, vol. 2, page 190 ; *Dictionary of Applied Physics*," by R. T. Glazebrook, vol. 3, pages 394 and 596.

BRITISH NAVAL POLICY IN THE PRE-DREADNOUGHT ERA.

THE dependence of Britain upon the possession of an adequate navy is a hypothesis that needs no elaboration in time of war, but it has not always been accepted at other times as a self-evident proposition ; and, in spite of the experiences of the preceding three centuries, it was left to an American, Admiral A. T. Mahan, to provide the first exposition of its essential truth that attracted anything like widespread attention. Mahan was not by any means the first to record naval history and attempt to draw lessons from it, but his famous book, *The Influence of Sea Power upon History*, first published just over 50 years ago, surveyed a wider field and took a wider view of it than any had done before. He was, to quote a contemporary commentator, "more historical than the strategists, more strategic than the historians, and more philosophical than either, . . . the first writer who has seen the problem steadily, and seen it whole." His own influence on naval developments in European waters powerfully supplemented the forces that were already at work, urging on the modernisation and expansion of the fleets of the Great Powers ; a story that, even yet, is not fully documented. The documentation of the British share in it, however, has now been considerably extended by the publication of a study by Mr. Arthur J. Marder (who, incidentally, is also an American) of *British Naval Policy*, 1880-1905.*

One of the first impressions that this book conveys is a reminder of the impermanence of international relations. For over three-quarters of the period with which it deals, the prospective enemies were Britain's allies of the war of 1914-18 ; to-day one of the allies of that war is an enemy, while another has deserted us and is now not far from being an enemy. The wisdom of the first Lord Stanhope, who urged that this country should have a navy adequate to perform all that might be needed, without dependence on foreign help, is here illustrated in a most practical and convincing manner.

Mr. Marder is a Research Associate of Harvard University. His declared object is "to make the first reasonably complete study of British Naval policy in all its ramifications in the vital pre-dreadnought era," and this he has certainly attained. He has made a thorough search throughout the current literature, in the Press, in published materials, in Hansard and the Blue Books ; and has been given the use of the correspondence of Lord Spencer—Gladstone's First Lord—and a quantity of hitherto confidential matter prepared by Admiral Sir John Fisher, concerning the policy of those strenuous years in which he made his "reforms" of various kinds. As has been stated, it is well documented ; and there are some particularly interesting appendices. The study begins in 1880, when British battleship policy was "to avoid the example of other Powers in laying down monster ships and to confine the armourclads built to the moderate dimensions of 10,000 tons, each costing not far from ¾ of a million." It ends with the reversal of that policy, with Britain preceding the other Powers in increasing the size of the battleship.

The period was one of great naval expansion, and in the first sections of his book the author seeks to analyse the causes of that expansion ; in part, the rebuilding of the French Navy, which had been in abeyance since the Franco-Prussian war, when France had had to devote all her resources to her army ; and, in part, the Russian naval building. The growth of these two navies, which threatened the supremacy of the British, he attributes firstly to what he terms "the new imperialism" ; in other words, to the search for a share in the opening-up of Africa. The history of international relations after 1880, he asserts, was in a large measure "the clash of imperialisms." England's position as a colonial Power was threatened and she must at all costs strengthen her navy. Students of the colonial history of that period will hardly agree with this diagnosis, and British readers will probably feel some impatience at the attitude of patronising superiority with which Mr. Marder looks down from an Olympian height on the foolishness and fears of our countrymen. A second reason given for the expansion is the old cry of the influence of the armament industry and the iron, steel and engineering trades associated with it. Because those trades "experienced great benefits from large naval programs," he assumes that it was they that caused the ships to be built—a singular example of the *post hoc, ergo propter hoc* fallacy. Manufacturers may well have welcomed the orders that came their way ; but this is far from proving that it was their desire for orders that set those orders in motion. He has the boldness to assert as an established fact that there is "no doubt as to which factor—patriotism or profit—really actuated the agitation for a large naval program." Yet he admits another element in expansion, so far as Great Britain was concerned, namely, a revival in the public realisation of the importance of the navy. Mahan's writings, the Navy League and the Navy Records Society, among other influences, shook the Englishman out of the lethargy into which he had fallen regarding his sea power.

From these political aspects of the causes of naval expansion, Mr. Marder passes to what he calls "the fundamentals of strategy." He recognises that the primary needs of Britain are security against invasion and against trade attack. For some unexplained reason, however, he elects to employ terms which imply an impression that the dangers relating to those matters were over-rated, and that those who advocated increases in the navy were not justified by the realities of the situation. So he speaks of "the Bogey of invasion" and of "the nightmare of the *guerre de course*." Yet invasion, with the fleet weakened as it had been by prolonged neglect, was far from being a "bogey," nor was the danger to British trade a mere figment of the imagination, as the word "nightmare" would seem to suggest. It is probably easier to take this detached view from a country situated 3,000 miles away from a continent which bristled with armies, in no danger of its food supplies, and not dependent for its existence upon a foreign trade which was exposed to attack in narrow waters by torpedo craft. The intentions of Admiral Aube were certainly plain enough. The modern Hun had little to learn from him, and it was no dream that he and his school were indulging in : "To-morrow war breaks out, a torpedo boat has sighted one of those ocean steamers . . . she will follow at a distance, keeping out of sight, and when night comes on will close with the steamer unobserved and send cargo, crew and passengers to the bottom, not only without remorse but proud of the achievement."

The torpedo boat had made an appearance as early as 1875, and was beginning to figure in considerable numbers in the 'eighties ; in 1886, the estimates provided 341,468*l.* for these craft and 2,394,834*l.* for armoured ships, an indication of the relative importance that was being attached to them. And the torpedo boat was not the only disturbing factor in the problem of construction ; new instruments and inventions were taxing the skill and the foresight of the constructor and the strategist, who had little or no practical experience to guide them, though the civil war in America had introduced the turret ship and some forms of mines and torpedoes, and the Austro-Italian war had given prominence to the ram. All had to be based upon speculation, and there was naturally a great diversity of opinion. There were advocates of the masted and of the mastless turret ship ; of the broadside ship ; of ships heavily armoured with a consequent sacrifice of gun power and of ships without armour, but with heavy artillery ; of ships with armoured belts confined to the midship section and having unarmoured ends, and of completely belted ships. Some were convinced that the torpedo boat had rendered the battleship useless ; while others, not going so far as that, argued that a strong flotilla with a fleet would compensate for an inferiority in battleships, a view that was held during the last war. In the region of trade warfare, for which both our most probable enemies were making their preparations with armoured cruisers, fast raiders ("corsairs," the French called them)

* London : Putnam and Company. [Price 31*s.* 6*d.* net.].

and torpedo craft, there was great uncertainty as to how defence was to be furnished. In the opening address at the Colonial Conference in 1887, it was stated that, "in the present circumstances of trade, merchant ships could not be adequately protected by convoy, even if ships of war could be spared for the purpose," though light convoys might be used on certain short routes. Many, in fact, most, naval officers took this view. Admiral Hornby, for instance, outlined a scheme of ocean patrols by strong cruiser squadrons stationed in all the principal focal areas—the Channel approaches, the approach to the Straits of Gibraltar, the offing of the African salient, etc. His calculations gave a cruiser figure of 186 ships; curiously enough, almost exactly the number of cruisers and armed vessels employed during the war of 1914-18, apart from destroyers. How to give defence against the torpedo flotilla was not as quickly solved. The Rattlesnake, the forerunner of the destroyer, made her appearance in 1886, and in 1892 the shipbuilding talent of the country evolved the destroyer.

From these questions of design, the author passes to other matters, and devotes a short chapter to the inauguration of the Two-Power Standard. Though that standard had been proposed after the drawing apart of England and France and the coming together of France and Russia after the Crimean War, it had not been adopted; but it had its origin long before, having been the accepted standard throughout the Eighteenth Century. The Admiralty's interpretation of the expression was a five to three superiority in battleships over France and Russia—the mere mathematical measurement by numbers was never regarded as sufficient. British security, depending wholly upon the Navy, called for a margin; not only because Britain's sea strategy made it necessary for her ships to be constantly at sea and exposed to the dangers of torpedo attack, mines and the risks of the sea, but also (as Goschen pointed out) to allow for the risk that a third Power might seize the opportunity offered, when Britain was involved in a war, to present some intolerable demands—the "jackal" policy of to-day. From this, Mr. Marder moves on to the natural sequel, the Naval Defence Act of 1889, that most salutary and necessary measure. A half-hearted programme of increase had been put forward in 1884-5 by Lord Northbrook, who explained its modesty by the uncertainty as to the best type of ship to build. "The great difficulty the Admiralty would have to contend with," he said, "if they were granted three or four million to-morrow, would be to decide how they would spend the money." The prevailing uncertainty as to the influence of the torpedo boat was indeed a major element in the matter; in the debate in 1886, it was asserted that the Nile and Trafalgar would probably be the last ironclads ever built by this country or any other, and Northbrook's successor, Lord George Hamilton, explained in 1888 that the reason why the Board did not lay down several ships simultaneously was that they might be obsolete or useless in ten or fifteen years, since design changed so fast, and speed increased.

Mr. Marder, who is very free with his contemptuous references to British policy, chooses to speak of the "blue funk" in which the Admiralty of that period worked. It was not "blue funk," but common prudence, to take account of the relative figures of the British fleet and of those of France and Russia, and also of the bitter Anglophobe spirit that was permeating France. Such words as "the Navy Scare of 1888" are both infelicitous and inappropriate to a serious study, suitable as they might be to the political purposes of the partisans of disarmament. It is the more curious that he should have made use of that term when he remarks, a few pages farther on, that "Admiral Bacon does not exaggerate when he looks on this year (1888) as marking the lowest level of efficiency that the British Navy had known since the middle of the 18th century." It was not ships alone that were lacking; there were neither enough big guns nor were the early breech-loaders successful, though this last was a disability not confined to the Royal Navy.

The naval position in the Mediterranean forms the subject of the next chapter. There, the situation left much to be desired. France, after giving a formal promise to Britain, in 1881, not to fortify Bizerta, proceeded to do so, thus obtaining a powerful base close to Malta. The problem of how to meet a Russian fleet based on the Black Sea and able, in spite of international treaties, to come into the Mediterranean, and a French fleet with Toulon and Bizerta as bases, became acute after the conclusion of the Franco-Russian Alliance in 1891. The whole volume of hatred of the Anglophobe French press was set in motion on the occasion of the visit of the Russian fleet to France. The strength of the British fleet was not such as to allow this situation to be viewed without anxiety. The question of an alliance with Italy was considered, but rejected. In view of experience in the present war, it is interesting to read the remarks of a senior British officer at this time: "I do not know what is amiss with the Italian navy. It is not in ships; it is not in officers . . . it is not in science . . . it is not in pluck and hard work; it is not in seamanship. Yet there is something amiss, something that I can't help being conscious of. And the upshot of it all is, that if I had a heavy job on hand here, I would rather, even if I had a very inferior force of my own, attempt it without than with Italian help."

The year 1893 saw a renewed demand for an increase in the Navy; Mr. Marder calls it the "Navy Scare of 1893." In using this term he seems to differ from his teacher, Professor Langer, who, in his *Franco-Russian Alliance*, after remarking that the Naval Defence Act had ended a rather prolonged period of lethargy, observes that France and Russia had followed suit between 1889 and 1892 to such purpose that the situation had become more critical than ever, and "the English had good reason to view the situation with uneasiness." "Scare," in these circumstances, seems at the least an inapt word. England had indeed a very slight superiority, if any, over the combined fleets. As everyone should know, an enemy's strength is not measured in numbers only; but, so far as numbers are a criterion, Britain at that time had 43 battleships built and 3 building to 25 and 9, respectively, of France and 9 and 8 of Russia; a total which, when completed, would give the country whose life depends on the sea 46 ships to 51 of her rivals—numbers which testify sufficiently to the unreality of Harcourt's assertion that "he would undertake to say that the superiority of the British Navy was never so great as now."

Very fortunately, a most able and courageous sea officer, Sir Frederick Richards, occupied the position of First Sea Lord. When Harcourt followed his audacious statement with a further one to the effect that the Sea Lords agreed with it, they refused to allow this misrepresentation of their opinions to pass. They threatened to resign unless it were repudiated. Harcourt was thereby forced to adopt a different line. The country owes a great debt to Richards for his courage and tenacity. The effect of the evidence afforded by the British programmes, of the Government's intention to preserve the navy's superiority, was to convince France that competition was useless. She abandoned the contest for the command of the sea and returned to the old policy of the *guerre de course*. Armoured cruisers now began to take the place of battleships, eight of these of from 21 to 23 knots speed, together with other fast vessels, being laid down. The Director of Naval Intelligence pointed out the danger to which British Atlantic trade would be exposed by a squadron of such ships operating from Dakar. The British reply was the Cressy class of armoured cruisers, of 12,000 tons; ships which, in Sir William White's opinion, could take their place in the line of battle. These were followed by others, the Powerfuls and Drakes.

But while this development was in progress a new claimant for sea power was showing his hand. Germany was moving towards the sea, with openly expressed antagonism to Britain and the declared intention of becoming a sea Power. The need for a margin now became more pressing and Richards pointed out the danger of the policy of numerical equality with France and Russia. In a war with these two Powers, he said, "we should have to trust to the forbearance of Germany, perhaps the greediest and most determined of our commercial rivals, not to take us at a disadvantage when so circumstanced." The subsequent chapters carry the story through the successive years of crises. Fashoda, bringing home to France the influence of the British Navy, gave a stimulus to her submarine building. Fisher had already recognised, in 1904, "the vast impending revolution in naval warfare and naval strategy that the submarine will accomplish," but his foresight was not shared by others. The torpedo menace was one of the factors in the decision to increase the battleship's speed to 21½ knots. In a curious extract from one of his writings he says that "no one would seriously advocate the building of battleships to fight other battleships," since armoured cruisers could do all that was needed: the justification of the type of new battleship was that she was "a glorified armoured cruiser." To-day the British battleships in the Atlantic are acting in that role.

Apart from the tone of some of the opinions expressed in this book, to which reference has been made, it is a real contribution to our knowledge of the naval policy of the period. Though much of its contents may be familiar to those who have their *Naval Annual*, Tirpitz's and Fisher's memoirs, Woodward's *Great Britain and the German Navy*, and other such works at their elbows, it brings together a mass of information not hitherto available; not least the revealing letters in the private correspondence of Spencer, Richards and Fisher, and the views of the Directors of Naval Intelligence on several questions. It should serve to put the people of this country on the alert against movements which result in the weakening of the Navy, such as those which injured it so greatly after 1918.

UNIVERSITY EDUCATION OF ENGINEERS.*

By Professor C. E. Inglis, O.B.E., F.R.S.

(*Continued from page* 365.)

Mathematics is a subject which differs from almost any other form of knowledge in that, to most individuals, it presents a ceiling above which it is impossible to rise. When a student is endeavouring to master a particular subject, lack of natural ability can usually be overcome by extra effort; but my teaching experience leads me to believe that this does not apply to mathematics, and the fact that most students in this subject possess a definite limitation and are unable to rise above it, does not necessarily betoken a lack of effort. Fortunately, the mathematical ceiling for most engineering purposes is not very lofty and against this barrier the majority of engineering students need not bump their heads; but its existence must be recognised in any system of engineering education, and a student's analytical ability should be tested at an early stage. Even if this ceiling is below normal, he may yet have the makings of a first-class engineer; but engineering principles must be expounded to him in language of a less advanced mathematical character; otherwise, at the best, he will be in the condition of "faint but pursuing," and at the worst, thoroughly dispirited, he may abandon the chase.

The most widely used tools of engineering mathematics are the differential and the integral calculus, including some of the simpler species of differential equations. Modern mathematicians are exceedingly scrupulous about the legitimacy of the operations they employ, but engineering students should not have their minds burdened with an overload of philosophical doubts. For instance, elaborate investigations relating to the convergency of series are quite unnecessary, since the direct application of simple arithmetic will soon reveal whether or no a series is numerically intelligible. Engineers in their mathematical excursions should not allow themselves to be intimidated by notice-boards which say "Fools step in where angels fear to tread." The eminent French mathematician D'Alembert gave much the same advice when he wrote "*Allez en avant et la foi vous viendra.*" The validity of a mathematical process may well be defended by the fact that it yields no obviously absurd results.

In teaching mathematics to students of normal ability, experience has shown me that an illogical method is often the best, and that a thorough drilling

* Presidential address to the Institution of Civil Engineers, delivered in London on Tuesday, November 4, 1941. Abridged.

in the technique of a process can with advantage be given before the reasons underlying the process are fully understood. Thus, in teaching the art of differentiation, although the teacher, for his own satisfaction, may be permitted to give a preliminary explanation of the processes and principles involved, at that stage his explanation is not likely to make much impression with the majority of his audience. But if, after a student has practised the technique and worked out numerous examples, the reason and purpose of what he has been doing more or less automatically and blindly is once again explained, the scales will fall from his eyes and the light of true understanding will enter and remain therein.

For higher flights of modern mathematics, I have a profound admiration mingled with awe and, though it may be sacrilegious to say so, this awe is now and then tinged with a slight feeling of mistrust; for as a famous mathematician has said, "Mathematics is sometimes more intelligent than the people who use it." For my own part, I am only happy with the findings of mathematics when I am not more than two or three steps away from my starting-point. A greater distance is seldom necessary; elaboration of mathematics in relation to engineering problems often betokens a paucity of physical conceptions and is apt to suggest that perhaps, before being placed in the mathematical machine, the problem had not been reduced to its simplest possible form.

Some such simplification or idealisation is always necessary before an engineering problem is susceptible to analytical treatment. This preliminary simplification calls for careful discrimination and sound judgment; otherwise, factors may be left out of account which are of vital importance. As a case in point, I may mention that, when the Bridge Stress Committee was investigating the oscillations set up in railway bridges by the impact of locomotives, it was only revealed at a regrettably late state of the experimental work that the factor which really dominated the problem was the damping induced by spring movement in the locomotive, and that a mathematical analysis which left this out of account could not be trusted to give predictions of any practical value. This, and many other cases which might be cited, point the moral that mathematical conclusions in relation to engineering problems can be accepted only after experimental verification, preferably on a full scale, since in default of this verification influences of the first order of importance may have been idealised out of existence and analysis may have been indulging in that futile form of exercise known as "barking up the wrong tree."

Although analytical dexterity is an admirable quality in any engineering student, this form of ability should not be overmarked in assessing his merits. Mathematics is merely a means to an end, and not a culminating glory. In preliminary examinations it is well to have separate papers on this subject to probe a student's depth of knowledge in this direction and to detect the shallows; but in the final examination, mathematics should be put in its proper perspective and viewed as a means to an end, this end being the solution of engineering problems and not a display of mere analytical dexterity.

Before leaving the subject of mathematics, I will just touch on that oft-debated question whether it should be taught by a man who is primarily an engineer or mainly a mathematician. It is very similar to the consideration whether French should be taught by an English-speaking Frenchman or a French-speaking Englishman. My own experience is that, in a teacher of mathematics to engineers, first-hand experience of its application to practical engineering problems is more important that superlative mathematical brilliance. You want for this purpose a man who has been all the way there and back again. The real mathematical artist has doubtless been all the way there, but his roots will have a tendency to come out of the ground, and he may find it difficult and irksome to descend to that level where, earth-born, the majority of his audience are constrained to shuffle along.

There is much truth in the saying that the proper study of mankind is man, and this precept should receive recognition in any liberal system of engineering education. Exclusive concentration on the materialistic and scientific aspects of his profession tends to produce in a student a certain narrowness of vision which subsequent experience may never wholly rectify. Too often one encounters the young man who assimilates with meticulous diligence every scrap of knowledge imparted to him, and in consequence passes all examinations with inevitable precision. His immediate advancement is thereby assured, and it is an absolute certainty that his diligence will carry him up to a certain level; but it is more than likely that lack of humanity and breadth of outlook will put a limit to any further advancement. At the time when his mind was most susceptible to treatment, his root development has been stunted by an over indulgence in an ill-balanced diet and a lack of those essential vitamins which the humanistic side of education alone can provide.

It is good to have communed with the great minds of the past, but that form of culture known as *literae humaniores* is a luxury which, in the case of an engineering student, must be left to individual enterprise, and the humanistic side of engineering education must perforce relate mainly to the present and the future. Engineering is now shaping the destiny of civilisation; it has vast potentialities for both good and evil and, side by side with his scientific training, a student should have his interest stimulated towards the humanitarian, the economic, and even the ethical responsibilities of the profession he is about to enter. To this aspect of engineering education the Council of the Institution are now giving earnest consideration. They have voiced their hope that engineering education of the future will stress more fully the economic aspects of engineering undertakings, the general principles of management, the organisation of works of construction, industrial psychology, and æsthetics in engineering design; and, as tangible evidence of this educational ideal, the University of Cambridge has been given a subsidy to provide special teaching in these subjects.

In addition to its cultural value, the study of æsthetics in engineering design is particularly appropriate to present circumstances, with such a vast vista of reconstruction work looming ahead. In this particular direction, engineering education in the past has taken little or no interest. Students are taught to design structures which are reliable and economical, but it is very unlikely that they are given the faintest indication that in beauty of form and harmony with surroundings there are other problems to be solved of almost equal importance. When accused of indifference towards æsthetic considerations, engineers have been prone to take refuge behind the plausible but pernicious doctrine that, if a structure is properly proportioned for the duties it has to perform, it must be automatically pleasing to the eye. That doctrine is one of those half-truths which can be very dangerous; for, mingled with truth, it contains an element of complacent self-sufficiency which, if allowed to remain unchallenged, will inevitably debase the whole status of the civil engineering profession.

Education will have performed a valuable service if it merely indicates to the rising generation of engineers that, in their designs, beauty of form as well as strength must be taken into account. Reasons why some structures please and others fail to do so, when pointed out, are fairly obvious; and, once a student's eyes have been thus opened and his interest aroused, an appreciation of beauty will, in most cases, grow up by personal observation. But good taste is not determined by a mathematical equation, and artistic treatment cannot be standardised by a code of practice. The most education can do is to sow the seeds. The cultivation of these is an individual responsibility, and it cannot be expected that all the seed sown will fall on fertile soil.

So far I have avoided the subject of examinations, but no talk on education can ignore completely this somewhat painful topic. A sweeping condemnation of the whole examination system is an easy way of gaining the approbation of one's audience; but, while I share the widespread mistrust of examinations as the ultimate test of mental ability, I mistrust even more the intellectual capability of the young man who fails with monotonous regularity to surmount every examination obstacle placed in his path, and in spite of all special pleadings, I consider the inference to be drawn from oft-repeated examination failures is all too obvious. It is easy to condemn the examination system, but even its most bitter critics have no clear-cut alternative to suggest. Written testimonials are of value, but only if one is in a position to assess the veracity of the writer, since writers of testimonials have this in common with those who inscribe epitaphs on tombstones, that they are not on their oath. Unless a testimonial is almost fulsome in tone it is apt to be interpreted as damning with faint praise; consequently there is a tendency to depict all geese as swans, or, at any rate, birds with very elongated necks.

There is no doubt, however, that education, particularly in Great Britain, suffers from a surfeit of examinations. Teachers have their merits assessed by the examination successes their pupils achieve; consequently they tend to keep their eyes focused on the examination syllabus, education degenerates into mere instruction, and instruction in its turn sinks to the yet lower depravity of cramming. The main purpose of examinations is to find out if a student's knowledge has become available for export. It is all too easy to satisfy oneself in this respect, but mastery over a subject has been attained only when one is able to expound its meaning and applications to someone else. Viewed from this standpoint, examinations cease to appear as vindictive impositions, to be circumvented with the minimum of effort. When one has reached that regrettable state of seniority which confers freedom from this particular infliction, the need of an examination substitute often becomes apparent. For my own part, if I want to acquire a working knowledge of some unfamiliar subject, I put myself down to give a course of lectures thereon. On the same principle, students of ability can derive great advantage by coaching their less gifted or less advanced brethren. The consolidation and clarification of their ideas resulting therefrom will be an ample reward for the expenditure of time and effort incurred. With the same end in view, undergraduate societies at which students read papers and discuss engineering subjects deserve every support. To encourage the timorous, variety and simplicity should be aimed at rather than depth and originality. A lively exchange of ideas on subjects within the comprehension of all, and opportunities for developing clarity in verbal explanations, should be their main purpose, and the conduct of these societies may well be guided by the dictum of a learned judge that "a restatement of the obvious is often more valuable than the elucidation of the obscure."

In connection with such societies, senior members of the profession can help greatly by giving talks about works which they have carried out, or engineering developments to which they have devoted special attention, and providing on these occasions an opportunity for students to converse with men of mature practical experience. In education, apathy can almost always be converted into explosive energy if only the right detonator is found, and such conversations may well kindle an enthusiasm which academic training has failed to arouse. With this object in view, the Institution of Civil Engineers is collecting a panel of its members who would be prepared to help, in this manner, the cause of engineering education. A list of possible helpers has been prepared and invitations have been sent out, but such a list must inevitably be incomplete, and I hope that any who feel a generous impulse to participate in this scheme will not hesitate to offer their services, although they may not have been formally approached to do so.

The prominence which should be given to workshop practice in the case of a university student has often been the storm-centre of heated controversy. Most certainly, some such training of a preliminary character is essential, but it is not the primary duty of universities to turn out skilled mechanics; they have neither the facilities nor the time for doing so, and the major part of this training must be post-graduate. Before a student takes his final examination he should, however, have achieved some familiarity with and some dexterity in the use of tools, and this qualification can be attained by workshop courses in the university or, alternatively, by experience in commercial workshops during vacations; usually, a combination of these two alternatives is advisable. There is also much to be said for a short workshop training sandwiched into a period between leaving school and entering the university. The manual dexterity a student acquires in such a course is of secondary importance; its primary value lies in the lessons in human psychology which this experience will consciously or subconsciously provide. The student may be too young to appreciate fully at the time the value of these lessons, but nevertheless youth to him at that stage is a great asset. He will, in consequence, find the workmen fatherly and helpful, and he will discover that they have a kindly and generous side to their nature which he may perhaps never fully appreciate if his first contacts with British workmen are delayed to a later stage. Apart from the foregoing considerations, a short interregnum between school and a university is excellent for character formation. It develops in a young man the knack of throwing out new roots in unfamiliar surroundings. Furthermore, it gives him the feeling that he has started his professional career and, in consequence, he does not enter the university regarding it as a school with a relaxed discipline.

To get the maximum benefit from this preliminary practical experience, respite from systematic tuition in theory may be permitted, for the time being; but, if this is done, the time should not exceed six months, otherwise a student's sensitivity towards book learning may receive a set-back which is more than temporary. Here, however, it is wrong to generalise, for I can recall several instances of a super-successful university career which had been prefaced by a full practical apprenticeship, during which only a meagre substratum of theoretical engineering knowledge had been acquired. But these were all exceptional cases; young men with great force of character and outstanding natural ability, who could hardly be affected adversely by any irregularity or inversion of the educational system. For normal university students, the serious part of their practical training must follow their university career, and, if education has achieved its purpose, the intelligent and orderly assimilation of this post-graduate practical training will have been greatly helped and expedited thereby.

(To be continued.)

11-IN. SWING CAPSTAN LATHE.

THE range of 5½ centre, 11 in. swing, capstan lathes manufactured by Messrs. Alfred Herbert, Limited, Coventry, has now been extended by the lathe, described as the No. 2D. Herbert capstan lathe, and illustrated in Figs. 1 and 2, herewith. The new lathe enables any one of eight spindle speeds to be obtained instantly without stopping the spindle and resembles the No. 2S, lathe in being motor-driven, this latter machine being the first small capstan lathe in which the old conventional belt drive from a countershaft was abandoned. The 11-in. swing above mentioned is that over the bed; over the cross-slide the swing is 5⅛ in., being thus equivalent to a 2⅜ in. centre lathe. It is, of course, suitable for bar work, the hole in the spindle being 1 1/16 in. in diameter. The maximum distance between the spindle nose and the capstan face is 18¾ in. and the working stroke of the capstan is 5½ in. The general view, Fig. 1, shows the main features of the new design clearly and may be compared, in order to show the advances made, with that of the 11-in. swing capstan illustrated and described in ENGINEERING, vol. 138 page 487 (1934).

The drive is by a four-speed pole-changing motor through a gearbox, which gives two speeds to a two-step cone pulley in the cabinet leg carrying the motor. Either of these two speeds is selected by appropriate movement of the ball-ended lever seen at the base of the headstock, the movements actuating a multi-grip plate clutch. The two-step cone pulley drives, through a belt, a matching pulley on the spindle. The spindle is started, stopped and reversed by the ball-ended lever seen at the top of the headstock. This lever can be operated by a touch of the finger and by flicking it momentarily into reverse, the spindle can be stopped almost instantaneously at any speed. Since the motor provides four speeds, which can be multiplied by two in the gearbox, a range of eight spindle speeds is available for one position of the belt on the cone pulley. A second range of eight speeds is obtained by moving the belt from one step of the pulley to the other.

The speeds are indicated on the conical dial, identified by a controlling star-wheel, at the top of the headstock. The small plate above the dial indicates the direction in which the starting lever lies for either the fast or slow speed ranges. Rotation of the dial actuates a change-speed switch selecting one of the four motor speeds and the speed chosen is doubled by the lever-operated clutch in the driving box. The spindle speeds on the standard machine comprise the fast range, of eight speeds, from 160 r.p.m. to 2,550 r.p.m., and the slow range, eight speeds from 50 r.p.m. to 810 r.p.m. To facilitate selection the numerals on the dial are coloured green for the fast range and white for the slow range. If tough materials are to be machined, the lathe can be supplied with a fast speed range of from 85 r.p.m. to 1,400 r.p.m., and a slow speed range of from 28 r.p.m. to 460 r.p.m.

The spindle is mounted on precision ball and roller bearings with double-purpose ball bearings to take the axial thrust in both directions. These bearings are stated to require neither attention nor adjustment, and to be practically free from wear. The spindle nose is formed with a hardened flange in order to accommodate different types of chuck. These may be, for example, a 1¼-in. draw-in chuck and automatic bar feed, the feed-table of the latter swivelling out of line with the spindle to permit bars to be inserted from the front end. This chuck is self-adjusting for the diameter of bars, provided this does not vary more than 1/32 in. Again, a hand-operated dead-length bar chuck may be fitted. This has a capacity of 1¼ in. for normal work and of 1½ in. for light bar and tube work; the grip is powerful and no end movement of the work takes place during gripping. For chuck work, a 6-in. Coventry concentric chuck, a Herbert air-operated chuck, or a four-jaw all-steel independent chuck can be fitted. The saddle carries a cross-slide with front and rear tool posts. Longitudinal saddle traverse is effected by the handwheel seen at the bottom of the headstock, this wheel being fitted with an indicator to enable length dimensions to be accurately duplicated. Six adjustable stops are provided for this motion. The cross-slide is operated by the firm's patent duo-rate hand feed mechanism which provides fast or slow feed at will. Both feeds are obtained by a handwheel on the saddle, the change from one to the other being made by a small lever.

The capstan slide is of improved design. The ways on the capstan saddle are completely covered by the slide, thus affording protection to the Vee and flat surfaces of the respective ways. The width is unusually great in order to give adequate rigidity to the capstan in all positions of its travel. This construction, in conjunction with the freedom from wear resulting from the covering of the ways, assists in maintaining alignment. The slide has two automatic feeds, of 80 cuts and 16 cuts per inch, respectively. The feed is derived from the spindle, transmission being by belt and two-step cone pulleys. A slipping clutch in this drive prevents damage should the capstan slide be fed into the cross slide. The feed shaft is mounted in ball bearings. The capstan slide has six self-selecting stops, the capstan being indexed automatically at the end of the return stroke of the slide. When desired, the indexing mechanism can be disengaged and the capstan turned by hand. The capstan is hexagonal and the standard outfit of tools includes a ½-in. Coventry diehead and four sets of dies.

In this connection an interesting auxiliary device is illustrated in Fig. 2. It will be obvious that, with the die-head shown, the capstan could not be rotated, as the diehead would foul the saddle. The sliding holder fitted, however, will allow threads of larger diameter to be cut than would be possible with the normal holder, since it will accommodate 1 in., 1¼ in., and 1½ in. Coventry standard and 2½ in. fine-thread dieheads, and the ¾ in. Tangic diehead. The holder, it will be realised, is traversed vertically by a roller and cam as the capstan is rotated. When this movement occurs at the end of a screwing operation, the diehead is automatically lifted while, when the capstan turns round for the screwing operation it is lowered into place again, exact alignment with the spindle being maintained. An alternative feed arrangement for the capstan slide can be obtained. This consists of a change-feed box giving feeds of 80 cuts, 160 cuts, 280 cuts and 560 cuts per inch. The change-feed box is driven by belt from the spindle, changes being made through sliding gears, of heat-treated nickel-chrome steel, operated by two levers.

The remaining features of the lathe require little comment, but it may be mentioned that the flat ways of the bed are hardened by Messrs. Herbert's Flamard process, these surfaces having a Brinell hardness of between 478 and 555. The bed has, virtually, three-point support, since the right-hand leg can be swivelled round a vertical axis. The lathe is thus self-accommodating for unevenness of the foundations and special levelling is not required. This construction renders the machine easy to install. A deep trough with an end sump is provided and an optional fitting in connection with this is a motor-driven pump for the cooling lubricant. It will be evident from the grease-gun prominent in Fig. 1 that this type of lubrication is used for some of the moving parts.

11-IN. SWING CAPSTAN LATHE.

MESSRS. ALFRED HERBERT, LIMITED, COVENTRY.

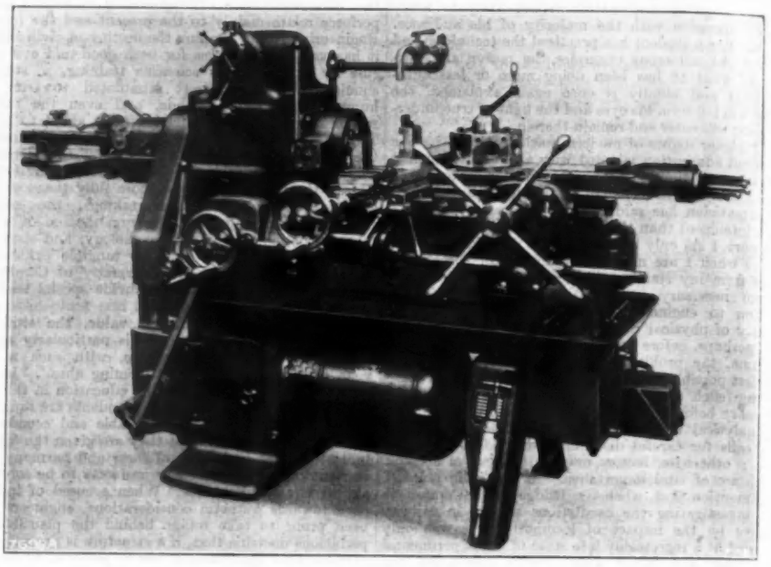


FIG. 1.

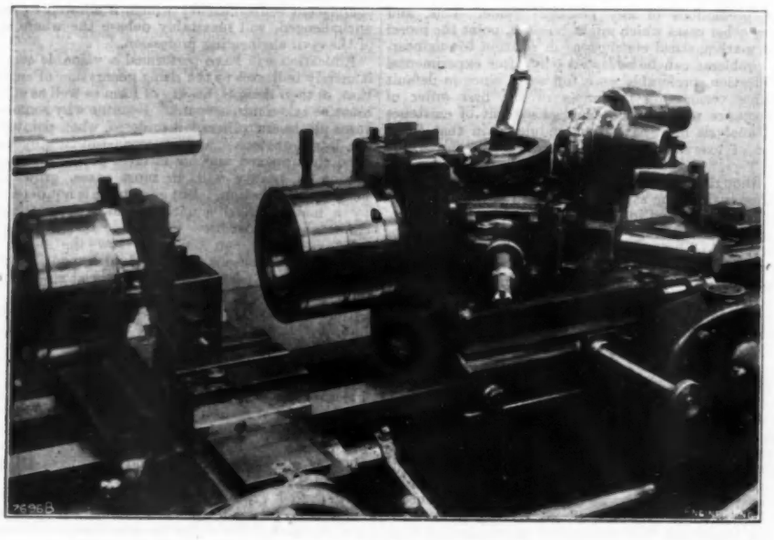


FIG. 2.

CORRUGATED SHEET-STEEL CATENARY DAM.

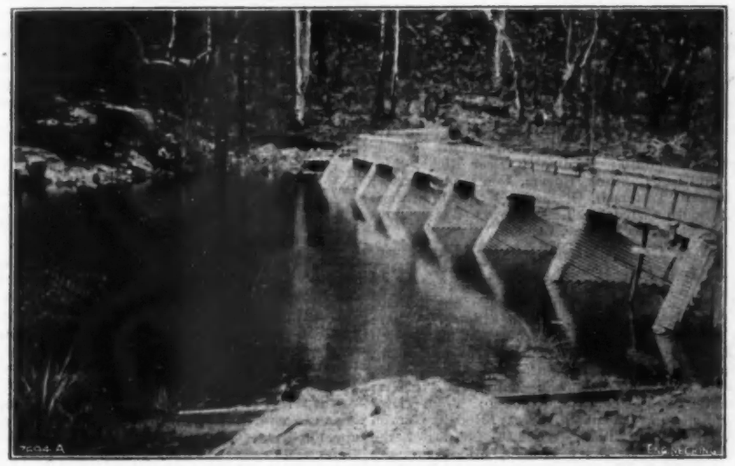


Fig. 1. Upstream Side of Dam Partly Completed.

CORRUGATED SHEET-STEEL CATENARY DAM.

Although the design and construction of dams has received a considerable amount of attention in Engineering, the examples dealt with have generally been of large structures. The corrugated sheet-steel catenary dam illustrated in Figs. 1 to 7, on this page and on page 390, is comparatively small, the total length of the crest being some 270 ft. and the greatest depth of water 24 ft. Nevertheless, the dam is of particular interest, the design being, as far as we are aware, entirely novel and possessing marked advantages over more conventional types, in that it can be more rapidly constructed and at a much lower cost. Other advantages will be evident in the course of this description. The dam has been designed and constructed by Mr. E. Giles Stone, M.Inst.C.E., M.I.E.A., Box 3385 R., G.P.O., Sydney, at his works at Narrabeen, New South Wales. As is generally known, climatic and geographical conditions render water supply in many parts of Australia precarious, numerous water-courses remaining dry for long periods but taking flood water at intervals. This water, flowing into the rivers to which the watercourses are connected, may often be wasted by spilling over the dams in the rivers and thus finding its way to the sea. It will be gathered from the illustrations that Mr. Stone's dam is across a watercourse of this nature; thus, the dam is flooded on the upstream side in Fig. 1, while the site is quite dry in Figs. 2 and 3.

Before describing the dam it is necessary to point out that none of the illustrations shows it in its completed state; for example, in Fig. 1 there are gaps underneath the crest over which, when it is completed, the surplus water flows. In some respects the new dam resembles the fixed deck dam sometimes used in the United States. This type of dam, in its simplest form, consists of triangular buttresses generally similar to those seen in the background in Fig. 2, the spaces between the buttresses being bridged by concrete slabs resting on the buttresses, the impounding, or upstream, face thus created making an obtuse angle with the bottom of the watercourse. Mr. Stone, however, does not employ concrete slabs which have, of necessity, to be thick, but adopts instead semi-cylindrical corrugated steel sheets curved away from the water flow. The sheets are thus in tension and the load-carrying principle is, roughly, analogous to that of the suspension bridge; hence the use of the term "catenary" as applied to the dam. To make this point clear it should be noted that the downstream side of the dam is that to the left of Fig. 4. The total length of the catenary portion of the dam is about 180 ft. and there are 11 spans, the catenaries being approximately of 8 ft. radius. The remaining length of the crest of 270 ft. is made up by a rock-fill embankment at each end having a reinforced concrete core, this core being clearly visible on the left of Fig. 4.

It will be evident by comparing Fig. 2 with Figs. 3 and 4, that the buttresses in the first-mentioned figure are not finished. The upstream edge is prolonged as shown in the two latter figures and an inclined reinforced concrete strut is led back on the downstream side to the solid rock at each buttress. The upstream edge is provided, moreover, with a bearing face as this edge takes the load on the catenaries. It will be evident, particularly in Fig. 6, that the catenary sheeting is continuous and passes round the bearing faces of the buttresses in a curve. This curve is about 8 in. in radius and is formed of sheets separate from the catenaries themselves. The sheets are too thin to permit of welding and are therefore riveted, an iron cement and treatment with an anti-corrosive compound being also employed. This construction is stated to be as watertight as is necessary, though if absolute watertightness were deemed essential it could easily be effected. The catenaries are of special corrugated steel sheets zinc-coated and given a final heat treatment. These sheets, known as Zincanneal, were supplied by Messrs. Lysaght, Newcastle Works, Limited, Port Waratah, N.W.S. The struts are of Tee cross-section and are seen in course of construction in Fig. 2, the method of reinforcement being clearly visible. The upper parts of some of the finished struts are seen in Fig. 3.

The buttresses are tied together by the crest of the dam, which, as may be distinguished in Figs. 5 and 6, is of a cross-section approximating to that of a flat-bottomed rail, though, of course, very much larger. The shuttering for the bottom web across two of the bays is seen in Fig. 3, the structure resembling hand-railing in this view being the reinforcement for the vertical web. This shuttering is supported by timber shores since the site was dry when this part of the work was commenced. Later, however, water accumulated up to the level of the catenaries, so that the shuttering of the other spans had to be carried on a temporary truss as shown in Fig. 6. The crest is not left in the form shown, but the ledges are filled in with rubble and the finished contour conforms to that of normal overshot weirs. It has already been pointed out that there is apparently a gap between the top of each catenary and the crest. These gaps, however, are closed by a continuous inclined concrete slab lying on top of the corrugated catenaries, the edges of which are embedded in it. The slab is covered with rubble, so that the total weight is sufficient to resist the upward thrust of the water above the catenary edge level. Below that level the catenaries easily carry the water load. They are, however, further strengthened by tie rods passing round the back and attached to yokes formed in the buttresses. The rubble on the catenary slabs is finished with concrete, the covering being formed at its lower edge with a gutter. The gutter is led to the banks at the sides of the dam and given a suitable inclination for run-off. At maximum flood water flow it is estimated that the depth of flow over the top of the crest will not exceed $\frac{1}{2}$ in. This water, being caught in the gutter, will run off to irrigate grassland at the sides below the dam, the surplus being led away by a drain. The downstream side of the dam, it is expected, will always remain dry.

The water is drawn from the reservoir behind the dam through a strainer situated in a chamber approximately midway along the dam, the position of this chamber being identified by the wall between two of the buttresses close together, as seen near the centre of Fig. 7. The chamber itself is seen in Fig. 2, and over it, on the downstream side, is a flight of steps giving access to the crest and visible on the right of Fig. 4. The foundation of the dam is sandstone in natural blocks similar to those seen in the background of Fig. 3. This rock is virtually impervious, but should any leakage develop it is impounded by another small dam farther down the watercourse. The greater part of the floor below the steel catenaries rests on made ground. It will be recognised that as no large masses of concrete resting on a more or less flat surface, as in a gravity dam, are involved, the problem of hydraulic uplift is not important; it may, indeed, be considered to be virtually non-existent. On the other hand, it is claimed that, by the employment of corrugated steel sheeting, a light type of dam can be built, of entirely adequate strength not only for a static load, but to withstand vibration and stresses due to water impact. The downstream side of the dam is finished with a rock and earth fill, with a suitable retaining wall of concrete. The position of this wall can be identified by part of the shuttering for it visible on the left of Fig. 3.

The main reason for the new design of dam is to enable water to be conserved at a low cost. This cost, Mr. Stone claims, is likely to be only one-third or one-quarter that of a gravity wall, although adequate stability is ensured. He suggests that the low cost makes it possible, by erecting catenary dams on suitable sites upstream of existing dams, to intercept large quantities of water which at times of flood run to waste over the spillways of these lower dams. This procedure would relieve the severe water restrictions at present obtaining in New South Wales. On one point only does Mr. Stone criticise the design. The life guaranteed by the manufacturers of the steel sheeting is 15 years, which he admits is not long enough. He has, however, been experimenting for a number of years on an anti-corrosive agent which is stable not only under fresh water conditions, but also when exposed to salt or brackish water. The nature of the base of this agent being such that it improves in water, its life may be indefinitely long and by the use of this anti-corrosive compound the life of the steel sheeting may be prolonged to a period exceeding that guaranteed by the sheeting manufacturers. We are indebted to Mr. Stone for the photographs from which our illustrations have been prepared, and to an article by him, appearing in *The Commonwealth Engineer*, for the information on which this account is principally based.

BLAST-FURNACE BLOWER PLANT IN THE UNITED STATES.

The employment of the turbine-driven centrifugal blower for blast-furnace air supply would appear to have become standard practice in the United States, and in its adoption Messrs. De Laval Steam Turbine Company, Trenton, New Jersey, have played a considerable part. Installing its first plant in 1928, the firm has progressively improved its designs and one of its recent installations, with a capacity of 85,000 cub. ft. per minute, illustrates this progress. The blower was supplied to Messrs. Great Lakes Steel Corporation, Detroit, Michigan, the blast-furnace plant of which consists of three furnaces having normal ratings of 500 tons, 600 tons and 1,000 tons a day, respectively. For regular service on the smaller furnaces two Ingersoll-Rand blower units, each of a capacity of 60,000 cub. ft. per minute are provided. The De Laval 85,000-cub. ft. per minute unit regularly serves the 1,000-ton furnace, and a 75,000-cub. ft. per minute De Laval unit is provided which is alternatively used for the 600-ton furnace and as a stand-by for the 1,000-ton furnace. The steam conditions of all three units are the same, the pressure being 400 lb. per square inch, the temperature 700 deg. F., and the vacuum 28 in. of mercury. Whichever of the three units is not in operation can always be started up at short notice, a vacuum being maintained in the condenser and turbine casing and the steam pipes being kept well drained, conditions which enable the quick starting characteristic of the impulse type of steam turbine to be utilised.

The improvements incorporated in the 85,000-cub. ft. blower compared with that installed in 1928, which had a capacity of 60,000 cub. ft. per minute, may be summarised as follows: water cooling has been discontinued, with a resultant simplification of design and reduced maintenance, and the heat of compression is retained in the blast air; the number of stages in the blower has been reduced from five to four without impairing the efficiency; and the balancing device has been perfected, so reducing the leakage loss at this point to the minimum. This device consists of a grooved disc at the back of the last impeller at the discharge end of the blower. The disc, although it does not make metallic contact with the opposing face, which is a babbitted ring fixed to the casing. The space within the ring is connected to the suction side of the blower, so producing an unbalanced thrust on the last impeller approximately equal to, though opposed to, that of the other impellers. The small axial load remaining is taken by the thrust bearing,

which is of the pivoted-pad type, and serves to locate the rotor axially. An important alteration in design relates to the mounting of the several elements of the plant. The former cast-iron bedplate has been replaced by one composed of heavy rolled-steel joists welded together. Pedestal bearings have been discarded in favour of fixed bearing brackets, the alignment of the unit, particularly under variations of temperature, being thus maintained. Liners have been placed between the turbine, blower, and coupling box, and the bedplate in order to minimise expansion stresses, and the construction of the blower wheel has been simplified in order to ensure satisfactory fit between the blades and the diaphragms. The vanes are of Z cross-section, a design which protects the rivets against the abrasive action of a dusty atmosphere.

The steam turbine is of the multi-stage impulse type, the steam economy of which is not dependent on small radial clearances. A new method of construction, at the high-pressure end ensures accuracy in nozzle angle and spacing. The diaphragms at this end are of the built-up type, the centre portion being a split disc machined all over. The individual nozzle elements, which are stainless-steel castings machined all over, are assembled in a groove at the periphery of each diaphragm and are welded in place. The diaphragms at the low-pressure end of the turbine are provided with moisture-collecting chambers which have proved effective in reducing the steam consumption and should add to the life of the blades at this end. The packing at the high-pressure end is a combination of labyrinth packing and carbon rings. The former consists of a grooved stainless-steel sleeve attached to the shaft and four labyrinth rings made of Nitralloy. Side pressure on the carbon packing ring stabilises it and provides additional sealing. Where the turbine shaft passes through the carbon packing, sleeves of hard polished stainless steel are provided. These sleeves can be replaced should they become scored. The flexible coupling between the turbine rotor shaft and the blower rotor shaft is completely housed in and is continuously lubricated so that wear is eliminated. The lubricating system of the machine incorporates a De Laval-Imo oil pump. The oil piping is welded wherever possible to reduce risk of leakage from joints. An auxiliary oil pump driven by a small steam turbine provides lubrication when starting up and acts also as an emergency set, as it is started up automatically in the event of a failure of the main oil pump.

The Askania control was used for the first time on blast-furnace blowers in the United States in this machine. With this type of control the main regulator is augmented by a correcting regulator, the movement of which is also controlled. This latter control is effected by a small displacement-type constant-speed sampling blower taking air from the suction side of the main blower. Any changes in the condition of the air handled by the sampling blower will deflect the correcting regulator and this movement will adjust the main regulator. All corrections for barometric pressure and for the temperature and humidity of the air are thus made automatically. The operator of the blast-furnace is responsible for making any change in the volume of air supplied, and his instructions to the blower operator are followed by a simple setting of the dial of the automatic regulator. The valve gear for admitting steam in correct sequence to the turbine nozzle chambers is hydraulically operated. The oil cylinder is situated below the floor line of the set in order to minimise the possibility of oil coming into contact with any high-temperature parts of the turbine. In addition to a powerful main hydraulic governor valve gear, a separate emergency governor is provided. This acts on a trip and throttle valve at 10 per cent. above the speed for maximum operating conditions. There is also a simple auxiliary device for limiting the maximum speed without tripping the throttle valve, the device being controlled by an Imo-type pump mounted directly on the end of the turbine shaft independently of the main lubrication system.

We are indebted to Mr. R. M. Rush, of Messrs. Dravo Corporation, Pittsburgh, Pennsylvania, for the information given above. We understand that Mr. Rush has paid considerable attention to the possibility of driving blast-furnace blowers by means of gas turbines utilising blast-furnace gas, and he estimates that the net thermal efficiency of the whole cycle of such an installation would be about 26 per cent., a figure which is notably higher than that for any steam-driven turbo-blower now in use.

High-Speed Merchant Shipbuilding.—An indication of the speed-up which is taking place in merchant shipbuilding in this country is afforded by two instances which have been communicated to us. A 10,700-ton tramp vessel has recently been placed in service only six months after the keel was laid, and a ship of the partly-fabricated type was launched four months from the date of the laying of her keel.

INSTITUTION ELECTIONS.

Institution of Structural Engineers.

Associate Members.—Wilfrid Butterworth, Boreham Wood, Herts.; Ian Alexander Cram, Huntingdon; George Cruickshank, Aberdeen; Wilfred John Dockman, London; Alexander Fowlie, Wolverhampton; Joseph Gimpel, London; Frederick Donald Green, Erith, Kent; William Henry Thompson Green, Chatham; James Colin Haigh, Peterborough; George Frederick Hodgson, St. Albans; Eric Holt, Stafford; Harry Gordon Partridge, Stafford; Frank Trevor Raleigh, Portsmouth; Ferdinand Oscar Riche, Edgware, Middlesex; Frank Rogers, Coulsdon, Surrey; John Edward Tattersall, Glasgow; Kenneth Edward Walker, South Croydon; Leslie Stuart Watts, London; Robert James Wilkins, London.

Graduate to Associate Member.—Cyril Edgar Brown, Gidea Park, Essex; Charles Wilfred Brown, Bath; Henry Archibald Coles, B.Sc., Leamington Spa; Ernest Patrick Cronin, London; George Eaton Dent, B.Sc., St. Vigeans, Angus; Peter Elliott, London; James McLachlan Fairlie, Glasgow; William Arch Gill, B.Sc., Stafford; Alec Sidney Haines, North Chingford, Essex; Eruch Jamshed Kambata, B.E., Bombay; James Edmondson Langhorne, Leeds; Archibald Parker Macdonald, Reading; John Victor Garland Shilston, Dagenham, Essex; Ronald Gordon Taylor, B.Sc., Brighton; Thomas Charles Leslie Trafford, Stafford; Albert Walker, Middlesbrough; Maurice Wilfred Watson, Nottingham; Leighton Melson Wingate, B.Sc., Lagos, W. Africa.

Student to Associate Member.—William Morris, Stockport.

Institute of Marine Engineers.

Member.—J. Broadley, Baillieston, Scotland; E. P. Combellack, Dunedin, New Zealand; S. P. Radford, Manchester; E. O. C. Rothwell, Belfast.

Associate to Member.—G. Guthrie, Newcastle-upon-Tyne; E. Pemberton, Runcorn.

BOOKS RECEIVED.

Thorpe's Dictionary of Applied Chemistry. By Professor J. F. Thorpe and Dr. M. A. Whiteley. Fourth edition, revised and enlarged. Volume V. *Feh.-Glass.* London: Longmans, Green and Company, Limited. [Price 70*s.* net.]

United States Bureau of Labor Statistics. Serial No. R. 1207. *Occupations and Salaries in Federal Employment.* By M. L. Smith and Kathryn R. Wright. Washington: Superintendent of Documents.

Massachusetts Institute of Technology. Department of Civil and Sanitary Engineering. Publication No. 79. *Abstracts of Selected Theses on Soil Mechanics.* Compiled under the supervision of Professor D. W. Taylor. Cambridge, Mass., U.S.A.: Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology.

The Ohio State University. The Engineering Experiment Station. Bulletin No. 109. *Highway Development. First Short Course on Roadside Planning, February* 28 *and March* 1, 1941. Columbus, Ohio, U.S.A.: The Director, The Engineering Experiment Station, The Ohio State University. [Price 60 cents.]

Post-War Questions. No. 8. *Is Liberty Lost?* By St. John Ervine. London: The Individualist Bookshop, Limited, 154, Fleet-street, E.C.4. [Price 6*d.* net.]

Department of Scientific and Industrial Research. Forest Products Research. A Handbook of Home-Grown Timbers. War Emergency Edition. London: H.M. Stationary Office. [Price 1*s.* 6*d.* net.]

Metal Aircraft for the Mechanic. A Practical Textbook for Metal Riggers, Ground Engineers, Technical School Instructors and Students. By J. Healey. Third edition. London: Sir Isaac Pitman and Sons, Limited. [Price 5*s.* net.]

Transients in Electric Circuits Using the Heaviside Operational Calculus. By Professor W. B. Coulthard. London: Sir Isaac Pitman and Sons, Limited. [Price 25*s.* net.]

Turning and Screw-Cutting. By W. F. Watson and W. Pitt. 51, London-road, Aston Clinton, Bucks.: Pitt's Popular Publications. [Price 2*s.*]

United States Bureau of Labor Statistics. Serial No. R. 1330. *Earnings and Hours in the Furniture Industry, February,* 1941. By V. S. Baril and A. C. Lakenan. Washington: Superintendent of Documents.

A Dictionary of Electrical Terms, Including 'Electrical Communication. By S. R. Roget. Fourth edition, revised and enlarged. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s.* 6*d.* net.]

New Railway Network Principles. A Project for Applying Them to British Railways. By J. F. Pownall, 110, Dale-end, Birmingham, 4: Cotterell and Company. [Price 2*s.*]

PERSONAL.

Mr. H. H. Berresford has been appointed managing director of Messrs. The Staveley Coal and Iron Company, Limited, Hollingwood, near Chesterfield. He has hitherto held the position of deputy managing director and commercial manager.

Mr. P. R. Angus, A.M.I.Mech.E., locomotive superintendent, New Zealand Government Railways, Wellington, has been promoted to the position of chief mechanical engineer.

Mr. V. D. Harty, B.A., B.A.I., received the Mullins Silver Medal of the Institution of Civil Engineers of Ireland for 1940-41, for his paper, "The Liffey Power Development. Concreting Methods," at the meeting of the Institution, held on November 3. At this meeting the Laurence J. Kettle Premium for 1940-41 was presented to Mr. R. C. Quinlan, B.E.

Sir Atul C. Chatterjee, G.C.I.E., K.C.S.I., has been appointed chairman of the Examinations Committee of the Royal Society of Arts.

Mr. D. Lyon McLarty, a director of Messrs. Malley's, Limited, Sydney, has been appointed Director of Engineering and Shipbuilding by the New South Wales Government. He joined the staff of the Cockatoo Island Dockyard in 1925.

Mr. W. A. Robotham, head of the tank development department of Messrs. Rolls-Royce, Limited, has been appointed chief engineer on tank design under Mr. Oliver Lucas, controller-general of research and development, Ministry of Supply.

Mr. Abineri, late of Messrs. F. A. Hughes and Company, Limited, Manchester, has joined the staff of Messrs. Specialloid, Limited, Friern Park, North Finchley, London, N.12, as a technical representative of the equipment division of their sales department.

Mr. Ben Hall, general manager and engineer to the City of Portsmouth Transport Department, has relinquished his position as a member of the Council of the Public Service Transport Association. Mr. C. R. Tattam, M.Inst.T., general manager of Bradford Corporation Passenger Transport, has been appointed to fill the vacancy. Mr. C. T. Humpidge, chief engineer of Nottingham Corporation Transport, has been appointed representative of the Association on the Joint Committee for Overhead Equipment.

The Minister of Supply has appointed Mr. C. J. Brockbank to be Controller of Abrasives. This new Control will be concerned with the supply of the raw material needed by the abrasives industry and with its best utilisation in the national interest. The address of the Control is Palace Chambers, Bridge-street, Westminster, London, S.W.1.

Admiral of the Fleet The Right Hon. Lord Chatfield, P.C., G.C.B., O.M., K.C.M.G., C.V.O., has accepted nomination as President of the Institution of Naval Architects, in succession to the late Viscount Stonehaven, P.C., G.C.M.G., D.S.O. The election of the new President will take place at an extraordinary general meeting of the Institution, which is to be followed by a luncheon at the Connaught Rooms, Great Queen-street, Kingsway, London, W.C.2, on Wednesday, December 10, at 12.30 p.m.

NOTES FROM THE SOUTH-WEST.

Cardiff, Wednesday.

The Welsh Coal Trade.—Operators on the Welsh steam-coal market experienced considerable difficulty in arranging fresh business last week. Collieries, generally, were kept well occupied in completing deliveries under contracts already on their books and existing contracts were sufficient to ensure the steady absorption of practically the whole outputs for some time to come. Business for essential war industries, gas, electricity and railway undertakings was given preference and deliveries to ordinary customers were consequently in arrears in some cases. Considerable interest was shown by customers in certain foreign trades, but in view of the necessity of conserving as much coal as possible for the home market, exports remained on a restricted scale. The general tone of the market continued to be firm. Producers generally had good bookings for the best large descriptions and offers were consequently made only sparingly. The sized sorts were still active. The demand was particularly keen for the bituminous small descriptions, the potential outputs of which were almost entirely disposed of for a long time ahead. Only a limited interest was shown in the inferior dry steam smalls, which were readily obtainable for early delivery and were dull. A sustained interest was shown by inland users for cokes which, however, were not easy to secure owing to the well stemmed position of producers.

The Iron and Steel Trade.—The position in the iron and steel and allied trades of South Wales and Monmouthshire showed no change during the week.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little change in the Scottish steel trade during the past week and plant has been kept fully occupied on orders of national importance. There has been a heavy demand for plates and sections and this demand is expected to increase considerably. Special and alloy steels are in steady request and there has been a reduction in the requirements of the shipyards. The consumption of boiler plates is very heavy as the boilermakers are being pressed for deliveries. The heavy steel industry is working at full capacity but the lighter side is not so fully employed. Makers of black-steel sheets still have a large amount of work on hand and fresh business has been coming forward in satisfactory volume. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade conditions are fairly active and the forward outlook is satisfactory provided the necessary raw materials are obtained. The re-rollers of steel bars report little change in the position and, although their order books are well filled, more could be easily undertaken. Stocks of semies have been accumulating recently and are now ample. The present prices are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—The demand for Scottish pig-iron is strong and consumers are pressing for deliveries. All available hematite is quickly taken up for priority orders so that none is left for other purposes; this also applies to basic iron. Foundry iron is moving more freely but makers are able to meet all demands promptly. To-day's market quotations are as follow:—Hematite, 6*l.* 18*s.* 6*d.* per ton and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Even in these days, when the vast volume of business being done is chiefly on Government account, the large steel and engineering works are endeavouring to satisfy the legitimate needs of ordinary commercial customers. Overseas trade is difficult to arrange, but efforts are being made to keep in touch with old-established customers in countries not under enemy control. In the raw and semi-finished steel branches there has been little change. Brisk business is being done in basic steel, and the call for acid steel has shown a steady rise during the past six months. Ample supplies of scrap are available, and imports of hematite and pig iron are sufficient in most cases. The heavy machinery and engineering branches are busy, and many important orders are on hand for equipment and products. Railway rolling-stock producers are busier than they have been for some time past. Wheels, axles, springs, tyres, and buffers are in demand and makers of wagons are more busily engaged. Steelworks and ironworks machinery and related plant is in strong demand, the latest contracts including rolling mills, hydraulic presses, bending machinery, strip and bar mills, and foundry equipment. The increase in the demand for steel of all types is indicated by the fact that more orders are circulating for furnaces. Electric-arc and high-frequency furnaces are being installed at local works, and gas-fired furnaces are being used to an increasing extent. Tool manufacture is one of the busiest sections of Sheffield industry, and all the important works are operating at full capacity. There is a strong demand for engineers' small tools and machine tools. Orders are being received for agricultural-machinery parts.

South Yorkshire Coal Trade.—Larger quantities of coal are moving from the collieries in this area. Industrial coal is in strong demand; steams, smalls, and slacks find a ready market; and locomotive coal is in better request. The house coal market is active. Foundry and furnace cokes are steady, and blast-furnace coke is a progressive section.

COKE-OVEN PLANT IN BRAZIL.—A complete by-product recovery coke-oven plant is to be installed by the Companhia Siderurgica Nacional, at Volta Redonda, near Rio de Janeiro, Brazil. The plant, which comprises 55 Becker-type coke-ovens and equipment for the recovery of ammonia, tar, benzol, toluol and other by-products, is to be built by the Koppers Company, Pittsburgh, U.S.A.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Although many authorised consumers of iron and steel have practically covered their requirements to the end of the year a fairly extensive business is still being done in materials required for purposes directly associated with the war effort. The production of most commodities is promptly absorbed, but deliveries are well up to schedule. Very little tonnage is available, however, for ordinary industrial requirements. Raw materials, with the exception of foreign hematite ore, are plentiful and, apart from hematite qualities, pig-iron supplies are fully adequate. Consumers of semi-finished iron and steel are still well placed with regard to stocks.

Cleveland Iron Trade.—Most of the foundry iron passing into use in this area is from the Midlands and as supplies from that quarter are likely to be well maintained the continued scarcity of Cleveland pig is of little importance. The output of the latter is light and intermittent and the prospects of an increase in the make are remote. Foundry iron consumers have no difficulty in placing orders with Midland makers and merchants are finding slightly increased business. The official quotations for Cleveland pig are ruled by No. 3 quality at 128*s.* delivered in the Middlesbrough district.

Basic Iron.—Basic-iron makers are still unable to spare any iron for the market, but their output is sufficient for the heavy demands of their own steelworks. In the continued absence of market transactions the fixed price of 120*s.* 6*d.* for basic iron remains nominal.

Hematite.—The slight changes in the hematite branch of trade are for the better. The shortage continues to necessitate the rigid restriction of distribution, and delivery licences are granted only for essential needs, but a slight increase in the make and the use of substitutes have appreciably eased the stringency. The recognised market values remain at the equivalent of No. 1 grade of hematite at 138*s.* 6*d.* delivered to North of England buyers.

Foreign Ore.—Importers of most descriptions of foreign ore have good stocks, and cargoes are coming to hand with satisfactory regularity.

Blast-Furnace Coke.—Little change can be reported in the case of Durham blast-furnace coke. The supply is abundant but holders have well-filled order books and are not pressing sales while local users are bought as extensively as they consider necessary. The fixed prices are firm on the basis of good medium qualities at 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—Re-rollers have had to draw on their stocks of semi-finished iron and steel, but the tonnage stored is sufficient for their needs and supplies of home products are expected to increase. Manufactured-iron firms are busily employed on heavy work and report some improvement in the demand for the lighter varieties of material. Constructional steel is in better request and the increasing call for special alloy steels necessitates a further enlargement in the make. Black and galvanised-sheet producers have numerous orders on hand, and ship, tank and boiler-plate manufacturers have as much work as they can deal with.

Scrap.—The supply of light iron and steel scrap is now more than sufficient for current needs but the demand for heavy grades, particularly for machinery metal, good-class steel and cast iron, is more than the merchants can meet fully.

WORLD TIN STATISTICS.—The current issue of the *Statistical Bulletin* of the Tin Research Institute shows that 19,400 tons of tin were produced in the world during September, 1941, as compared with 21,800 tons in September, 1940. The total production for the first nine months of the present year was 185,900 tons, against 165,400 tons in the corresponding period of 1940. The consumption of tin in the United Kingdom totalled 2,079 tons in August, 1941, compared with 2,418 tons on the preceding month and 2,322 tons in August, 1940.

THE LATE MR. L. H. MORRISON.—News of the death, on September 20 at Port Washington, New York State, of Mr. Lacey Harvey Morrison, has reached us from the United States. Mr. Morrison was editor of the monthly journal *Diesel Power*, a position he had occupied since 1931. Prior to this he was associate editor of the journal *Power*. In his younger days he was an engine designer and subsequently a consulting engineer, and, during the war of 1914-18, served as a lieutenant in the United States Army Ordnance Department. Mr. Morrison, who was the author of *American Diesel Engines*, *Oil Engines*, *Diesel Engineering Handbook*, and other works, was a member of the American Society of Mechanical Engineers and of the Society of Automotive Engineers.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Wind-Tunnel Experiments on Model Reaction Turbine Blades," by Dr. M. R. Youssef, to be read by Dr. T. W. F. Brown.

INSTITUTION OF PRODUCTION ENGINEERS.—*North-Eastern Section:* To-night, 6.15 p.m., The County Hotel, Newcastle-upon-Tyne. (i) "How to Get the Best Out of Your Broaches," by Mr. W. A. A. Holmes. (ii) "The Grinding Wheel and Production," by Mr. F. W. Vickery. *Edinburgh Section:* Saturday, November 22, 3 p.m., The North Bristol Station Hotel, Edinburgh. "Electrical Deposition of Metals and the Anodic Treatment of Aluminium," by Mr. Stanley Murray.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Saturday, November 15, 2 p.m., at Messrs. The General Electric Company, Limited, Magnet House, Kingsway, W.C.2. Joint Meeting with THE ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS. "Electric Furnaces," by Mr. V. O. Cutts.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Western Branch:* Saturday, November 15, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "Munitions Labour Supply Organisation," by Mr. W. H. Denholm. *Institution:* Friday, November 21, 2.30 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. General Meeting. Thomas Hawksley Lecture: "A Century of Tunnelling," by Mr. W. T. Halcrow.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, November 15, 2.30 p.m., The Engineers' Club, Manchester. "Applications of Photography in Engineering," by Dr. D. A. Spencer.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Midland Centre:* Saturday, November 15, 2.30 p.m., The Hotel Metropole, King-street, Leeds. "The Characteristics and Performance in Service of High-Voltage Porcelain Insulators," by Mr. J. S. Forrest. *North-Western Students' Section:* Saturday, November 15, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. Ordinary General Meeting. Chairman's Address, "A Review of Electrical Engine-Speed Indicators for Aircraft," by Mr. J. Dean. *Institution:* Thursday, November 20, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. "The Characteristics and Performance in Service of High-Voltage Porcelain Insulators," by Mr. J. S. Forrest.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, November 15, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Annual General Meeting.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Saturday, November 15, 6 p.m., at Messrs. Robert Hyde and Son, Limited, Stoke-on-Trent. "The Engineering Aspect of Artillery Equipment," by Major Weir and Mr. W. Steeds.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, November 18, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. General Meeting. "Some Developments and Applications of Mechanical Refrigeration," by Mr. P. B. H. Brown.

SOCIETY OF GLASS TECHNOLOGY.—Wednesday, November 19, "Elmfield," Northumberland-road, Sheffield, 10. 9.50 a.m., Special General Meeting to amend certain Rules of the Society. 10 a.m., Ordinary General Meeting. Symposium on "Glass Furnace Problems." (i) "High-Temperature Recuperators," by Mr. J. B. Wagstaff. (ii) "Some Fundamental Aspects of Heat Transmission by Radiation from Flames and Furnace Linings," by Mr. E. C. W. Smith, Dr. A. L. Roberts and Professor D. T. A. Townend. 2 p.m., Symposium on "Furnace Problems." (i) "A Proposed Method for Calculating the Performance of Glass Tank Furnaces," by Dr. W. M. Hampton. (ii) "Principles Underlying the Calculation of Furnace Performances," by Mr. W. A. Moorshead.

INSTITUTE OF FUEL.—Thursday, November 20, 2.30 p.m., The Queen's Hotel, Leeds. "Liquid Pitch Fuel," by Mr. E. Brett Davies.

INSTITUTE OF WELDING.—*North-Eastern (Tyneside) Branch:* Thursday, November 20, 7 p.m., The Mining Institute, Neville-street, Newcastle-upon-Tyne. "Practical Implications of High Peak Hardness Values Induced on Welding Carbon-Manganese-Molybdenum Steels," by Mr. H. Bull.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*Manchester Centre:* Saturday, November 22, 3 p.m., The Engineers' Club, Albert-square, Manchester. General Meeting. "The Prevention of Accidents, from the Technical Aspects," by Major E G. Beaumont.

CORRUGATED SHEET-STEEL CATENARY DAM AT NARRABEEN, N.S.W.

(*For Description, see Page* 387.)

FIG. 2. REINFORCEMENT OF BUTTRESS STRUT.

FIG. 3. COMPLETED BUTTRESS STRUTS.

FIG. 4. CORE WALL FOR ROCK-FILL SIDES.

FIG. 5. UPSTREAM FACE OF DAM.

FIG. 6. TEMPORARY TRUSS FOR CREST CENTRING.

FIG. 7. UPSTREAM FACE SHOWING OUTLET CHAMBER.

CENTRAL PLANNING OF INDUSTRIAL ELECTRICAL EQUIPMENT.—The Directorate of Industrial Electrical Equipment (D.I.E.E.) of the Ministry of Supply has been formed within the organisation of the Controller General of Machine Tools and Equipment to undertake central planning in connection with industrial electrical equipment. The equipment which comes within the scope of the Directorate comprises: (*a*) rotating machinery, including motors, generators, converters and frequency changers; (*b*) static equipment, including transformers and rectifiers, and condensers for power-factor correction and phase conversion; and (*c*) switchgear and control equipment, including starters, regulators, switches, fuses, switchboards, distribution boards, circuit breakers and isolators. Equipment required for Admiralty purposes; for ground radio or air-borne purposes; and for generation, transmission or high-voltage distribution by electricity-supply or industrial undertakings, is excluded from the scope of the Department. It is the duty of the Directorate to assess supplies and demands and to secure the most efficient use of production capacity. An Electrical Advisory Panel, comprising Messrs. H. W. Bosworth, F. V. Brook, D. Maxwell Buist, E. C. Holroyde, L. J. Hunt, J. S. Ramsden, T. G. Travis, and J. R. Walton, has been set up to give advice and assistance. The Director of Industrial Electrical Equipment is Mr. S. F. Steward, 35, Old Queen-street, S.W.1.

ENGINEERING.

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We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730 and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, NOVEMBER 14, 1941.

VOL. 152. No. 3957.

UNIVERSITY ENGINEERING EDUCATION.

SOME problems there are in most walks of life which involve so many variables, and contain so few recognised constant quantities, that the accomplishment of any generally acceptable solution appears to be almost a hopeless task. For many years, the formulation of an ideal working basis for the education of engineers has seemed to be one of the most intractable of these problems ; and likely to continue so, if only by reason of the multiplicity of activities to which the general term of "engineering" is categorically applied, the innumerable gradations that exist between completely repetitive practice and the more rarified preoccupation with pure theory, and the many directions in which the art and profession of the engineer make contact with other arts, sciences and professions. Not infrequently it has happened, however, that when the mind of man has succeeded in producing a particularly discouraging tangle of ideas, precepts, theories and experimental determinations, there has arisen some clear thinker, possessing more than average skill in separating the trees from the wood, who has been able to grasp the essentials of the problem with unerring precision and to construct therefrom a platform on which others may rest awhile to recover their breath and their bearings.

The presidential address which Professor C. E. Inglis delivered to the Institution of Civil Engineers on November 4, and which we are now in process of reprinting in ENGINEERING, is definitely entitled to a high place among such pronouncements ; as, indeed, its reception clearly indicated to be the opinion of the immediate audience. It was concerned solely with university education of engineers and thus made no attempt to deal with the many controversial points appertaining to the principles of general engineering education, or of engineering training as distinct from education ; but the place of the university in providing the technical equipment which a proportion of engineers, at least, must have, is itself a topic that has given rise to much difference of opinion among those who have passed through university engineering departments and those who have not, as well as among the employers to whom graduates must look for their subsequent livelihood. The address is likely, therefore, to be read and discussed by a much wider audience than that for which it was prepared.

Thirteen years ago, the then President of the Board of Education (Lord Eustace Percy) appointed the Committee on Education for the Engineering Industry "to advise the Board of Education as to the scope and methods of the Board's inquiry into technical education for the engineering industry," and some ten years have now elapsed since their report was published. Comparatively little of the report was devoted to university engineering training, but the fact was noted that "the bulk of University Engineering students who enter the Industry are engaged in research, testing, design and salesmanship, rather than in productive engineering and its management." The Committee expressed the view that "the comparative absence of University-trained men on that side merits careful consideration," adding that "there is always a danger in the divorce of men with high technical and theoretical qualifications from the practical side of an industry, and our evidence shows that, with certain noteworthy exceptions, this divorce is found in Engineering." They considered that "the Universities ought to supply a valuable, though by no means the only, element in the administration of the Industry," but recognised that it would be necessary, "if more University students are to be obtained for the works, to show that there are reasonably good prospects in this direction." It was their expressed belief "that University authorities are in serious doubt on this point and are unable to get a clear lead from employers."

Evidently, there has developed an increasing appreciation, since that report appeared, of the potential value of the young engineer who has had a university education. Professor Inglis observes that "engineering firms are, with increasing persistence, asking for young men of exceptional ability," although, not infrequently, they do not seem to know how to make the best use of that ability when the recruits have been acquired. He suggests that one main obstacle is the existence of that "stratum of high resistance and poor permeability" into which are absorbed those whose limited capacity at once prevents them from attaining the highest positions and impedes the ascent of others who might be able to do so. His solution, here put forward, not for the first time, but deserving renewed emphasis, is the provision of more posts in the nature of personal assistants to managers and directors, wherein young men can be set to study special problems calculated to develop their originality and brain power. Such experience, he considers with good reason, by bringing them into close contact with managerial work, would fit them the sooner for high responsibility and might help to correct the opinion, all too prevalent, "that the mentality of the technical man is too narrow for the highest positions industry has to offer."

This proposal, of course, is a natural development from Professor Inglis' primary hypothesis that a university should cater for the needs of those who —without any suggestion of class distinction, as he was careful to point out—are expected to become "the future officers in the army of civilian engineers," in which the role of non-commissioned officers will normally be filled by students from the technical schools. For many directorial positions, no doubt, the training that a technical school can give is ample, especially if, as is now possible in so many centres, it can be carried to the attainment of a degree as evidence that an accepted standard of knowledge has been reached. The university, however, presents so much greater opportunities in other directions that it is only reasonable to expect a higher level of administrative capacity in those who are capable of profiting fully by its advantages. It is hardly an exaggeration, indeed, to regard the ultimate degree as the least of the benefits that a university affords, though it may be looked upon as almost the greatest that a technical-school student can expect to derive, apart from the development of innate ability, which should be equally attainable in both. A fundamental difference between the educative value (as distinct from the instructive value) of a university and that of a technical school is just that difference which was long ago recognised to exist between the university and the training college for teachers, in the field of general education. The student at the university mixes with others whose outlook and prospective futures, in a majority of cases, are widely different from his own, and, even at that comparatively early

stage, is receiving valuable training as a "mixer" which is certain to stand him in good stead in later life. The student who attends a training college for teachers spends his days exclusively in close association with other intending teachers; a circumstance which undoubtedly accounts for much of the peculiar narrowness of vision that is not uncommon among the lower pedagogic ranks in particular. The technical-school student of engineering is saved from this disability in some measure by the essentially educative nature of much of his eventual life's work; but the tendency is there, nevertheless. Some of the larger schools are able to counteract it to some extent by encouraging social activities, but they are seldom able to compete with the amenities of a university in this respect. The curriculum may be too crowded to admit of much definite instruction in the humanities, as Professor Inglis recognises; but the friendly contacts, the widely different points of view that a university student has such excellent opportunities to encounter, and the appreciation of the significance of the diverse social and intellectual strata of which a university affords a cross-section, are themselves an education that no amount of mere book-learning can parallel. The address concluded with that admirable anonymous petition "Give me a good digestion, Lord, and also something to digest," etc. Professor Inglis himself has certainly provided the engineering profession and industry with "something to digest." All who are interested in the future well-being of engineering will join in the hope that their digestion may enable them to derive full benefit from the feast of reason that he has set before them.

ETHER SPACE.

Deliberate interference with broadcasting services during the war, so far, has been less than might have been expected in view of the intellectual and moral status of one of the main parties concerned. This immunity may be due to a realisation of the facts that broadcasting interference is a game at which two can play and that a service which has never had to close down during an air-raid may possibly be less vulnerable than one which has frequently been forced out of action. Broadcasting is an important aid to any country engaged in war, but is probably more vital where the Press is so strictly controlled that no intelligent person can be expected to take any notice of what it says. It is true that the broadcasting service is equally controlled, but while individuals can ignore the newspapers, care is taken that they cannot do the same thing with the wireless. They will hear it willy-nilly, and although the fact that it is merely an instrument of propaganda may be generally realised, much effect can be achieved by saying the same thing often enough. The rulers of Germany have a lively appreciation of the value of "damnable iteration." Possibly, however, this suggested fear of reprisals is not the reason why our services have been comparatively unmolested; widespread interference is, perhaps, being retained in hand as a valuable weapon in a future attempted invasion.

The way in which the broadcasting authorities of the world are carrying on amid the present welter, and the fact that the British Broadcasting Corporation is able to maintain overseas services in forty different languages, illustrate the remarkable technical development of wireless science, both at the transmitting and receiving ends. This does not mean, however, that conditions are entirely satisfactory and that progress in the next decade, comparable to that in the last, may be looked upon simply as a matter of technical development. The space available in the ether for practicable wavelength bands is limited, and as broadcasting services are more intensively and extensively developed in all countries, serious trouble will arise unless drastic and technically-sound measures are taken to distribute the available space fairly between the various claimants. A number of international conferences have dealt with this matter, but the decisions arrived at have not been entirely satisfactory. It is probable, as Sir Noel Ashbridge suggested in his presidential address to the Institution of Electrical Engineers on October 23, that a new attempt to reach a satisfactory compromise will be made after, or as a part of, the future peace conference.

Whatever form that conference may take, it should certainly furnish an opportunity to restrain some of the more aggressive nations in their claims on ether space and allow the whole matter to be discussed on a broadly fair basis. Sir Noel pointed out, by implication, that the problem has never been impartially considered on technical grounds. There had been delegates at some conferences "who almost proudly disown technical knowledge and only recognise the existence of technical facts if they happen to reinforce their own political view." Some countries' demands have arisen "from political considerations rather than from a straightforward desire to give a service to their own nationals," while in some cases the siting of stations has been determined with the idea of "flooding some particular portion of a neighbouring country with propaganda," rather than serving the maximum number of people in the country concerned. The handling of this matter entirely as a technical problem, were such a thing possible, would form an excellent opportunity for that more direct control of world affairs by scientific men, for which the British Association is calling. The idea that a purely scientific committee should be allowed to allocate wavelengths behind closed doors is, however, we fear, but a dream.

Broadcasting has become so familiar, and so much a matter of everyday life, that it is, at times, difficult to realise how very recently it has become an important factor in the comity of nations, and in their estrangement. The first international conference to deal with the matter met in Washington in 1927; this was followed by others in Madrid and Cairo in 1932 and 1938. Similar meetings concerned with the distribution of wavelengths in Europe alone were held in Geneva in 1926, Lucerne in 1934, and Montreux in 1939. The European situation is probably the most difficult and is certainly the one of most direct interest to us. The Geneva conference was held at a time when the general development of wireless stations, with resulting unintended interference, was assuming the status of an international problem. The public service had been started in this country in 1922 and the company at that time operating the service undertook to provide eight regional stations, each of a capacity of about 1 kW. These stations were completed, but, with an additional station in Belfast, served a population of only 21 millions out of a total of 46 millions. The coverage was later increased by constructing eleven satellite stations, and finally by the construction of the 1,600-m. station at Daventry. As this station had a capacity of 25 kW to 30 kW, and, according to Sir Noel, became "perhaps the best-known broadcasting station in Western Europe," it may well have had considerable influence in arousing the general realisation of the fact that wavelength allocation was an international question, and may have largely inspired the Geneva conference.

This latter conference, which resulted in the number of wavelengths available in this country being reduced from 21 to 12, was held before broadcasting had developed to its modern intensity and the whole matter had to be re-argued at the Lucerne meeting of 1934. The outcome of this second attempt was not entirely satisfactory. There was a tendency to favour the smaller countries, which had been slow in establishing broadcasting systems, at the expense of the larger. Several stations were placed on the same wavelength in a way that Sir Noel states was unworkable. Channel separation was also insufficient. In the long-wave band, there were not enough channels to allocate one to each country, which raised acute controversy that was as much political as technical. The upshot of the matter was that a number of countries did not sign the plan which was drawn up, and refused to be controlled by it.

As the world conference held in Cairo in 1938 made certain wave-band changes, the further European one was held at Montreux in 1939 to modify the Lucerne plan in terms of them. As it met at a time of great international unrest, it is a matter for some surprise that it succeeded in drawing up a plan which was signed by a large majority of the countries taking part. The efficacy of the plan has not been tested, as it had not been put into operation when the war broke out; it may now be looked upon as a dead letter. It is of interest, however, to hear from Sir Noel Asbridge that in many respects it was not technically sound. This presumably may again be put down to the action of delegates controlled by political and not by scientific interests. There were many channels shared between different countries, naturally radiating different programmes, the ratio of field strengths between two sources being taken as 100 to 1. In Sir Noel's opinion this ratio should be 200 to 1 if obtrusive interference is to be avoided. He states that, in some cases, the plan would not even have provided the 100 to 1 ratio. What the outcome would have been had the plan gone into operation it is not possible to say, but Sir Noel thinks that many of the projected stations would probably never have been built and that a working compromise would have been reached.

The Cairo conference allocated, for Europe, a medium-wave band of 545 m. to 192·3 m., and a long-wave band of 2,000 m. to 1,132 m. Were every station allotted a separate channel, with 9 kc. per sec. separating them, these bands were to accommodate 126 stations. This separation is actually rather low; the figure adopted and worked to in the United States is 10 kc. per sec. As the number of stations provided for in the Montreux plan was 340, it is not difficult to understand why the channel separation was taken at the minimum possible value. Even with this procedure, however, the plan clearly necessitated the sharing of wavelengths between two or more stations in many cases. If 340 stations each radiating a different programme is to be accepted as the basis for any future plan then no conference, technical or other, will be able to avoid this dual, or triple, allocation of wavelengths.

It is this aspect of the matter which makes it clear why the drawing up of a really satisfactory arrangement will not, and indeed cannot, be left to a purely technical committee. Europe is a large place with a great variety of communities, but, none the less, it is difficult to believe that it requires 340 different wireless programmes. The first line of approach towards a reduction of this excessive figure is an increase in the number of stations in each country working on the same wavelength. This requires that they shall radiate the same programme and the representatives of many countries at the various conferences have contended that such a procedure is not acceptable. It may be hoped that one of the achievements of the peace conference will be to make the intransigent countries realise that they must make it acceptable. For stations radiating the same programme, the ratio of field strength necessary if obtrusive interference is to be avoided is but 2½ to 1, as compared with 200 to 1 for different programmes.

Assuming that this procedure of dually, or multiply, radiated programmes has been accepted, or imposed, the matter then moves back into the technical sphere. Such a programme must originate in one studio and in practice is transmitted to the various radiating points over the trunk telephone lines. This was the method, for instance, by which the original eight British stations were linked to the 11 satellite stations. Sir Noel states that one difficulty is that in some countries the trunk telephone circuits are not of a sufficiently high quality to make this procedure feasible. The reply to this appears to be that such countries must take steps to bring their trunk telephones up to the required standard if they desire to build large numbers of broadcasting stations. Many of them have shown no reluctance to spend large sums on broadcasting for propaganda purposes and there is no good reason why they should not divert some of their funds to legitimate technical ends. Assistance in reducing the excessive number of broadcasting stations might also be furnished by more extensive use of relay exchanges distributing wireless programmes on telephone or special lines; on the Continent, this has been done only in Holland and Switzerland.

NOTES.

RETURN OF BUILDING AND CIVIL ENGINEERING LABOUR.

THE Minister of Works and Buildings has issued an Order (S.R. & O., 1941, No. 1642) calling for a return from all persons who employ labour engaged in building or civil engineering work. The Order, however, does not apply to those who were required to register as building or civil engineering contractors under Regulation 56AB of the Defence (General) Regulations, 1939. The main purpose of the return is to obtain information regarding labour, engaged in building and civil engineering, in industries other than these two industries themselves. The returns will, therefore, include employees engaged in maintenance work as well as on new building and civil engineering work, who are in the service of persons other than registered builders and civil engineering contractors. All such employers, in whatever industry they may be, are required to furnish returns of any workmen engaged by them in building and civil engineering. Information is required concerning the number and the trades of persons engaged in these activities and also regarding the value of the work carried out by the employer in October, 1941. The trades concerned are joiners and carpenters, if engaged on operations connected with building and civil engineering and not on shop work; bricklayers; slaters and tilers; painters; plasterers; plumbers; glaziers; and builders' labourers. In other words, the Order relates to all persons engaged generally in the construction, reconstruction, alteration, repair, maintenance, decoration or demolition of buildings or fixed works of construction. This includes excavation and levelling, the making of earthworks and foundations, the laying of pipes and sewers, the construction of roads and railways, track laying, and similar works. Copies of the form, No. B.C.E.4, on which the return is to be given, were made available at local offices of the Ministry of Labour and National Service on November 12. The forms must be filled in and returned to the Ministry of Works and Buildings (Registration of Builders), Sanctuary-buildings, 18, Great Smith-street, London, S.W.1, not later than November 22. The Ministry of Works emphasises that in no sense does the return constitute a registration of employers of building and civil engineering operatives. The Order calls merely for a return of information and this should be furnished by employers and not by individual employees.

CO-OPERATION FOR PRODUCTION.

It was in keeping with the motto, "Arts and Commerce Promoted," which adorns the façade of the Royal Society of Arts building in John Adam-street, Adelphi, that Sir Edward Crowe, K.C.M.G., chairman of the Council of the Society, should have selected "Co-operation for Production" as the subject of the inaugural address which he delivered to the Society on November 5. The greater part of it was devoted to an explanation of the functions of the Regional Boards of the Production Executive, and, more especially, the part that they have played and are playing in adjusting the machine-tool capacity of the country to the fluctuating demands of the munitions programme. Incidentally, as Sir Edward pointed out, the British machine-tool industry owes its continued existence in great measure to Russia, which took some 70 per cent. of the exports in this category during the lean years 1929-31, placing orders which amounted to not less than 10,000,000*l.* in value. These were financed by the Export Credits Guarantee Department; there were no defaults in payment, so that, commercially, the transaction was eminently satisfactory. Turning to the Regional Boards, which were originally known merely as "Area Boards," and were offshoots of the Industrial Capacity Committee of the Production Council, Sir Edward Crowe explained that there were eleven of them, and that they were now responsible to the Production Executive. The regions, with their respective headquarters, were: Northern (Newcastle-on-Tyne); East and West Riding (Sheffield); North Midland (Nottingham); Eastern (Cambridge); London and South Eastern (London); Southern (Reading); South Western (Bristol); Wales (Cardiff); Midland (Birmingham); North Western (Manchester); and Scotland (Glasgow). Each Board consisted of 19 members, comprising representatives of the fighting Services, the Ministry of Labour, the Employers' Confederation, the Trade Union Council, the Machine Tool Control Committee, the Ministry of War Transport, the Raw Materials Department, the Board of Trade, and the Ministry of Works and Buildings. In each body, therefore, there were a number of experienced men who knew each other and knew their way about Government departments, thus forming a valuable information bureau or liaison centre for industrialists, available without charge to any who might need it. The Boards had no executive functions, but they could and did give valuable guidance, and could assist an inquirer to obtain, say, an urgent increase of machine-tool capacity, through the Clearing Centres that had been set up in several Regions. Through the medium of these Clearing Centres, machine tools and cutting tools (or tool capacity) could be interchanged as might be necessary to remove production bottle-necks. The work of the Regional Boards was not limited to machine tools, however; for example, the London and South Eastern Board had initiated two movements which had had very satisfactory results. The first was a system of grouping factories for roof-spotting arrangements, one of the group being linked by telephone with some convenient anti-aircraft battery, which reported the position and direction of flight of enemy aircraft. This information was plotted on a map, and guided decisions whether or not to take cover. The second innovation was a grouping of factories for the purpose of arranging to stagger the hours of work, in order to distribute the pressure on local transport facilities. Sir Edward mentioned that there were now some 35 such transport groups, covering about 400,000 workpeople. By such means, and by linking firms with departments concerned with labour supply, export trade, upgrading and training, etc., the Regional Boards were giving much practical aid in securing the general co-operation that was essential to maximum production.

THE BRITISH RECORDS ASSOCIATION AND PAPER SALVAGE.

The address by the Master of the Rolls (Lord Greene) which was read on Monday, November 10, at the annual general meeting of the British Records Association, of which he is President, referred more especially to the protection against enemy action of public documents of national importance; much had been done, he said, to remove these to places of comparative safety, and, though some damage had occurred, it was gratifying to report also that there had been a surprising amount of successful salvage. The discussion that took place at the meeting, however, on the motion for the adoption of the ninth annual report, centred largely upon the evident danger that documents of value should be permanently lost by the indiscriminate destruction of accumulations of old papers, the nature of which was not appreciated or was even deliberately ignored in the urgent drive to secure waste paper. The majority of such documents, in the categories with which the Association is most concerned, are likely to be of a legal character; but there are other forms of records, with which the Association is also concerned, and which are even more exposed to ill-directed destruction. The Council for the Preservation of Business Archives has made some headway in securing the collaboration of firms who are willing to assist by exercising discretion in their clearances of old papers; and we have previously mentioned the expert knowledge that the Science Museum, the National Maritime Museum, the Newcomen Society, and similar organisations are prepared to place at the disposal of firms or individuals who are uncertain whether particular records of technical work and progress should be preserved, or whether the national interest would be better served by pulping them. It is much to be desired that a wider use should be made of such advice. The urgent need for waste paper is not likely to suffer by the exercise of care and discrimination of this kind, for it is probable that the expert opinion will condemn, as not worth preservation, considerable quantities of papers that the owners might have been tempted to withhold; and, in any case, the amount of paper represented by material adjudged to be of documentary value is unlikely to exceed a fraction of 1 per cent. of the total pulped. The need for waste paper is not being exaggerated in the official appeals, and we believe that the engineering industries alone could find, from among their old files, discarded shop prints, time sheets, stores chits, etc., a substantial proportion of the 100,000 tons that Lord Beverbrook requires immediately. The present is an excellent opportunity to institute a clearance that, in many cases, is likely to be overdue; but there must be still many engineering documents in the country which, though no longer in current use, are worth more to the nation and the industry in their present form than as pulp. We should be pleased to put inquirers, who may be in doubt about the value of such papers, into touch with competent advisers, to the dual end that valuable material shall not be destroyed to little purpose, and that material which is being uselessly preserved shall be released, to contribute to the national need.

MILLER MEMORIAL MEDAL.

Welding has now taken a secure position as a constructional process in practically every engineering sphere. The progress in its application to shipbuilding has been remarkable and a position has now been reached in which the all-welded ship has ceased to be a novelty. The award of the Miller Memorial Medal of the American Welding Society to Mr. David Arnott, Vice-President and Chief Surveyor of the American Bureau of Shipping, on October 20, is a fitting recognition of this state of affairs. As the medal is awarded for conspicuous contributions to the art and science of welding, probably no better choice of a recipient, in his own sphere, could have been made than that of Mr. Arnott. It was in 1925 that he became Chief Surveyor of the American Bureau of Shipping, and in 1927 the body laid down full classification rules for all-welded vessels, being the first classification society to do so. It is contended by some authorities that this method of construction leads to a saving of weight of as much as 20 per cent. as compared with riveting, the proviso being added that the hull shall be designed specifically as a welded structure. It is also claimed that welding results in an increase in propulsive efficiency and that a welded hull is less liable to damage than a riveted one. As is well known, welding is now extensively employed in Admiralty work in this country. In the United States, agreement on ship-welding practice has been reached between the American Bureau of Shipping, the Bureau of Marine Inspection and Navigation of the Department of Commerce, and the United States Navy. Welders certified by any of these bodies are accepted as qualified by the others. This satisfactory position is largely due to the work of Mr. Arnott in the important position he holds. The valuable work he has been able to do is based on extensive experience acquired in a wide field. Educated at the Royal Technical College, Glasgow, he served his apprenticeship with the Fairfield Shipbuilding and Engineering Company. He obtained office as a surveyor of the British Corporation for the Survey and Registry of Shipping in 1901. In 1917 he was appointed the Corporation's Principal Surveyor in Canada and, in 1918, became Deputy-Chief Surveyor of the American Bureau of Shipping.

THE NEWCOMEN SOCIETY.

The Newcomen Society for the Study of the History of Engineering and Technology was founded in 1920 and has therefore attained its majority; a circumstance that justifies the use, for once, of its full title, in recording that the annual general meeting, which was followed by the anniversary meeting, was held on Wednesday, November 12, at the Institution of Mechanical Engineers. The occasion was marked by the presentation of a short paper on "The Beginnings of the Society," by Mr. Arthur Titley, M.I.Mech.E., of Birmingham, to whom belongs the credit for having originated it, and who was the first president. An abridgment of this historical note is given on page 394. It is to

be regretted that no such authentic record exists of the founding of the Institution of Mechanical Engineers, the exact details of which have been the subject of some controversy which, for many years, there has been no original founder left to resolve. The ordinary meeting concluded with a paper by Mr. R. Wailes, M.I.Mech.E., on "Suffolk Windmills—Part I, Postmills," containing the fruits of an exhaustive technical survey of the corn-grinding windmills of this county, carried out by Mr. Wailes between 1937 and 1939 on the joint behalf of the Society for the Protection of Ancient Buildings and the Suffolk Preservation Society. He had previously visited all the mills in 1926, and noted that, in the ensuing eleven years, the number of working postmills had been reduced from 37 to ten. Seven mills had been completely demolished, and 20 had become derelict. At the annual general meeting which preceded the ordinary meeting, it was announced that Mr. E. Lancaster Burne had been elected President of the Society in succession to Colonel C. E. Davies, of New York, who is the first American member to have served as President.

Intensive Training Scheme in Engineering.

In consequence of the action which is now being taken of transferring highly-trained technical personnel from industry to the Services, a request for the provision of further training facilities in technical colleges has been made, to the Board of Education and the Scottish Education Department, by the Technical Personnel Committee set up at the request of the Minister of Labour and National Service under the chairmanship of Lord Hankey. The Committee desires that intensive courses in various branches of engineering of six months' duration should be made available to industry. After taking these courses, personnel withdrawn at an appropriate level from industry may be returned to employment, thus minimising the loss entailed by the demands of the Services. The employees who will be able to profit by the proposed courses will be, generally speaking, those who hold the ordinary National Certificate in mechanical or electrical engineering, or who have been awarded the Higher School Certificate or the Senior Leaving Certificate of the Scottish Education Department and have had at least one year's industrial experience. Holders of the full Technological Certificate of the City and Guilds of London Institute would also be suitable candidates, but it is not intended to restrict trainees to holders of these and similar qualifications, since other workpeople may be fully qualified to benefit by the courses. Employees selected for training will have the status of holders of awards granted by the State and will receive, in addition to free tuition, allowances at the rate of 160*l.* per annum in London and 130*l.* outside London, if living in lodgings; and 90*l.* per annum in London and 75*l.* outside London if living at home. The courses will be provided at 104 municipal technical colleges and similar teaching institutions in England, four in Wales and eight in Scotland. The question of staffing is one of great importance and considerable difficulty and, where necessary, industry will be asked to co-operate by releasing suitably-qualified employees, preferably those who have already had some experience of teaching, to make good any shortage of staffs. Briefly, the procedure for the recruitment of students will be as follows: firms, after selecting suitable employees, should get into touch with a technical college and book places. If there is no college within easy travelling distance from the students' homes, the firm should send to the Board of Education, or, in the case of Scotland, to the Scottish Education Department, a statement of their requirements. As soon as sufficient applicants have been accepted to form a class of, say, 20 students, colleges have been asked to commence work with the least possible delay. Communications relating to the scheme should be addressed, in the case of English and Welsh firms, to the Secretary, Board of Education, Branksome Dene Hotel, Bournemouth, Hampshire, and in the case of Scottish firms to the Secretary, Scottish Education Department, St. Andrew House, Edinburgh, 1. The heading, "Intensive Training Scheme (Engineering)," should be quoted.

OBITUARY.

MR. FRANK PICK.

It is with regret that we record the sudden death of Mr. Frank Pick, which occurred at his home in Golders Green on November 7. Mr. Pick, who will be remembered mainly for his work as a member of the London Passenger Transport Board, was born at Spalding, Lincolnshire, on November 23, 1878. He received his education at St. Peter's School, York, and was subsequently articled to Mr. G. Crombie, solicitor, in that city. In 1902, Mr. Pick qualified as a solicitor, with second-class honours, and in the same year entered the service of the old North Eastern Railway Company under Sir George Gibb, who was then general manager of that undertaking. Mr. Pick, who had gained the LL.B. (London) degree with first-class honours in 1903, worked successively in the statistics office, the district superintendents' offices at Sunderland and Newcastle-upon-Tyne, the rates office and, finally, the general manager's office. In 1906, when Sir George Gibb took over the management of the Metropolitan District and London Electric Railways, Mr. Pick came to London with him, and when Sir George retired in the following year, Mr. Pick was transferred to the staff of Mr. A. H. Stanley, now Lord Ashfield, who succeeded Sir George Gibb. In 1909, Mr. Pick was appointed traffic-development officer and, three years later, commercial manager. In these capacities he was engaged in building up the system of London omnibus routes and in other duties of an administrative nature.

In 1917, Mr. Pick was appointed by Lord Ashfield, then President of the Board of Trade, to take charge of the household fuel and lighting branch of the Coal Mines Department under the late Sir Guy Calthrop. He was responsible for the preparation and administration of the Orders governing the retail distribution of coal and its rationing for domestic use until 1919. In 1921, Mr. Pick was appointed assistant managing director to the Underground Group of Companies and, in 1924, assumed full administrative control under Lord Ashfield. He became managing director in March, 1928, and, on July 1, 1933, on the formation of the London Passenger Transport Board, was appointed vice-chairman of the Board under Lord Ashfield. He continued in this capacity until his retirement on May 18, 1940. Subsequently Mr. Pick visited British ports, on behalf of the Minister of Transport, to investigate methods whereby the discharge of cargoes could be expedited, and, towards the end of 1940, was appointed Director-General of the Ministry of Information. He relinquished this appointment after occupying it for only four months, however, and was then requested to investigate the possibility of utilising more effectively the canals and waterways of this country. This task was completed in May last. Mr. Pick was a foundation member of the Institute of Transport and served as President in 1931-32. He was an honorary member of the Royal Institute of British Architects, a member of the London and Home Counties Traffic Advisory Committee, a member of the Crown Lands Advisory Committee and late Chairman of the Council for Art and Industry of the Board of Trade.

MR. W. N. WESTON.

We regret to learn of the death, on November 1, of Mr. William Newton Weston, who was well known to users of electric cranes and other hoisting appliances as a director and former engineering manager of Messrs. Herbert Morris, Limited, Loughborough. He was nearing the completion of his 65th year, having been born in Hull on December 21, 1876. Mr. Weston received his general education in Bradford and in 1890 entered upon a five years' apprenticeship with the then Blackman Ventilating Company, subsequently Messrs. James Keith and Blackman Company, Limited. The first three years he spent in the firm's Bradford branch, after which he was transferred to the drawing office in their head office in London. In 1895, on completing his apprenticeship, he was sent to Bristol to take charge of the branch office in that city, but returned to the London staff in 1897. In the following year, he was appointed to the Leeds office, returning again to London in 1899 and remaining there until 1902. During this period, he was principally engaged in the design and erection of drying plant, but was also responsible for a large fan installation for removing smoke and fumes from the retort house of the Plymouth gasworks.

In May, 1902, Mr. Weston left London for Stalybridge, where he joined the staff of Messrs. Robert Dawson and Company and was engaged for some three years on the design and construction of air and water heaters, drying plant, centrifugal fans and pumps. He relinquished this appointment in 1905 to commence business on his own account in London as a manufacturer of similar heating, ventilating and drying equipment, and carried out a number of such contracts in the ensuing two years. In September, 1907, however, an opportunity occurred to join the staff of Messrs. Herbert Morris and Bastert, Limited, at their Empress Works, Loughborough, and of this he availed himself, thus beginning a connection which lasted for more than 34 years. Soon after his appointment, he became engineer manager at Loughborough and, about 25 years ago, was elected to the directorship which he still held at the time of his death. Mr. Weston was a member of the Institution of Mechanical Engineers, having been admitted as an associate-member in 1902 and transferred to the grade of member in 1908.

THE FOUNDATION OF THE NEWCOMEN SOCIETY.*

By Arthur Titley, M.I.Mech.E.

Appropriately enough, it was at Heathfield Hall, built by James Watt in 1790, and his residence for the rest of his life, that the first idea of forming the Newcomen Society arose. On the first day of the Watt Centenary Commemoration meeting in Birmingham, September 16, 1919, I was taking tea in the tent at Heathfield with the late Mr. John W. Hall, afterwards one of our presidents, when I suggested to him that we should form a society for the study of engineering history. He laughingly said, "Well, you are the first to suggest that," visualising, I suppose, a party of elderly engineers groping over the scrap-heap, searching for relics of their pre-apprenticeship days. He added, "But if you will start it, I will become a member."

It was on the next day, September 17, that a party of those who attended the Commemoration went to Ocker Hill in a motor char-à-bancs to see the old Watt engine of 1777, belonging to the Birmingham Canal Navigations, working under its own steam. There was a fair-sized party in the coach, most of whom were unknown to me. Among them was our late member, Mr. Alfred G. Scholes, an old Soho man, as his father was before him, who kept up a running commentary on the doings of Soho Foundry and its personnel. Among the company I noticed one who, alert and keen, was evidently making critical mental notes on what Mr. Scholes was saying. I think I need hardly say who that person was. When we alighted at the gates of the pumping station at Ocker Hill, I spoke to Mr. H. W. Dickinson (for the first time) and made the suggestion to him. He at once agreed, and said "We will find you in London half-a-dozen members; but the man you want to know is Mr. Rhys Jenkins," to whom he then introduced me. Shortly after this, being in London, I called upon Mr. Loughnan Pendred and on Dr. T. E. Lones (at that time an examiner in the Patent Office). Both welcomed the idea.

The matter was followed up in London by Mr. Jenkins and Mr. Dickinson, and in Birmingham by myself. On May 5, 1920, we held a meeting at my office in Queen's College Chambers, Paradise-street, at which seven prospective members were present. We formed a provisional Birmingham Committee consisting of W. H. Dugard, J. W. Hall, H. C. James-Carrington and myself, and reported what we were doing to Mr. Dickinson. We arranged that he should take similar measures in London till we could meet there. Accordingly the meeting took place in London on June 4, 1920, being held by the kindness of Mr. Pendred at the offices of *The Engineer*, at that time at 33, Norfolk-street, Strand. It was at this meeting

* "The Beginnings of the Society: a Note on the Attainment of its Majority," by the first President. Read at a meeting held at the Institution of Mechanical Engineers, London, S.W.1, on Wednesday, November 12, 1941. Abridged.

that the Society may be said to have taken concrete form. Fourteen prospective members were present. I reported what we had done in Birmingham and a general discussion took place as to the conduct of the Society. On the proposal of Mr. Jenkins, I was asked to act as President, and a London Committee was elected consisting of Messrs. Dickinson, Jenkins, E. Wyndham Hulme and Pendred, with the first-named as hon. secretary to collaborate with the provisional committee already formed in Birmingham. Further discussion took place on that very important point as to what should be the name of the Society and various suggestions were made. It was felt that some name, brief, with an implied historical appropriateness, was needed. No solution was reached and the meeting left this important point to be settled by the Committee.

The next step, and a very memorable one, was an invitation from Mr. Pendred to the Committee to dine with him that evening at the Savage Club. There, in that wonderful home of the Club in the Adelphi, overlooking "the River of Thames," a very pleasant party found inspiration. The name to be borne by the Society was discussed at length. To name it after some eminent engineer of old, such as Watt, seemed at first very natural, but we thought that this might not be entirely free from notes of discord inherited from the past. It was to Mr. Pendred and Mr. Dickinson that inspiration finally came, and we all agreed to adopt the historical name of Thomas Newcomen, of Dartmouth, Devon, the man who first drove a piston through the agency of steam. Happily, all the persons who were at this historic and pleasant dinner are still active members of the Society.

Our first ordinary general meeting, and it is this that we now commemorate, was held on Friday, November 5, 1920, in the Court Room of H.M. Patent Office, Southampton-buildings, W.C.1, by kind permission of the Comptroller. The paper was given by Mr. E. Wyndham Hulme, at the express invitation of the Committee, and its subject matter was appropriately "Introduction to the Study of Historical Engineering to the Year 1640." It was accompanied by an exhibition of rare books from the Patent Office Library. The election of 25 members was announced, and at the next Committee Meeting, on January 27, 1921, 27 more were elected.

The first of many pleasant Summer Meetings was held in Birmingham on June 16 and 17, 1921. The first annual general meeting was held on December 15, 1921. The Society had now set forth on its career. Looking back through these twenty-one years and browsing through the *Transactions* issued during this period, I feel that the Society has established for itself a position of which we may well be proud, and which ensures the continuance of its progress. It is a great satisfaction to me to have seen the friendly spirit that has throughout marked its development. Its good fellowship has marked its history and many abiding friendships have been made between us.

NOTES FROM NORTH AMERICA.

An extensive reorganisation of certain parts of the Canadian Department of Munitions and Supplies, under Mr. C. D. Howe as Minister, has been announced at Ottawa. Four new branches, each under a director, are to be formed, dealing respectively with gun and tank production, ammunition production, munitions contracts, and industrial planning and engineering. Work of the first three branches was formerly handled by the Munitions Production Branch. The Industrial Planning and Engineering Branch will co-ordinate the former Army Engineering Design Division with a newly formed Industrial Planning Division. Professor R. E. Jamieson, of McGill University, recently appointed Director-General of the Army Engineering Design Division, will now be associate director-general with Mr. W. F. Drysdale, but will remain as chief of the Army Engineering Design Division. Mr. J. F. Pringle has been appointed Chief of Transportation for the Canadian National Railways, with headquarters at Montreal, according to an announcement made on September 15 by Mr. N. B. Walton, vice-president of operation, construction and maintenance for the National Railways. Mr. Pringle, prior to this appointment, was General Superintendent, Southern Ontario District, central region, with offices at Toronto. In his new appointment, he will have supervision of transportation matters generally throughout the entire system. Mr. Pringle, who is a native of Cornwall, Ontario, began his service with the Canadian National Railways in November, 1919, as an assistant engineer in the engineering department at Montreal and continued in that position until 1923, when he was made transportation engineer to the Chief of Transportation. In 1925, he was made assistant to the Chief of Transportation and later in the same year he was transferred to Toronto as assistant general superintendent of transportation, succeeding to the office of general superintendent of transportation in August, 1932. In 1936, he was appointed general superintendent, Southern Ontario district, which position he held until his present appointment. He was one of the Canadian National officers lent to the National Railways of Mexico during the winters of 1929-30 and 1930-31 to assist in modernising and reorganising traffic methods on the Mexican lines.

The Phelps Dodge Corporation, New York, will shortly complete a 40,000,000-dols. new open-pit copper mine at Monenci, Arizona, that is expected to yield about 5,000 million pounds of metal during the next 30 years. Located in what is considered to be one of the world's great low-grade copper ore fields, where the yield is about 18 lb. of copper per ton of ore, the mine is scheduled to produce at least 450,000 lb. of copper daily, adding some 82,000 tons yearly to United States production, which will total about 1,100,000 tons in 1941. United States copper production depends upon twelve mines, of which seven are in Arizona, two in Utah and one each in Montana, Washington, and Tennessee.

Prompt government action is urged by the Mexican Confederation of Chambers of Commerce and Industry to relieve what they call an alarming shortage of iron and steel, and the high prices of those commodities in Mexico. War conditions are making it difficult to obtain supplies from abroad, principally from the United States. Mexico's building construction boom, and the great use of steel by the Mexican Government on a large irrigation programme, are also adding to the difficulty. Mexico's production of iron and steel, 93,179 metric tons in 1940, falls far short of the nation's requirements, the Confederation stated. It is recommended that the Government should provide special facilities for the exploitation of the numerous iron deposits that exist in Mexico, either by State operation or by assisting private enterprise. The Confederation urge that there should be full protection of capital invested in the iron and steel business to ensure sustained operation.

Each measuring 1,100 ft. long and 150 ft. wide, three dry docks now under construction in the United States are considered to rank with the world's largest. Two are under construction at the Philadelphia Navy Yard and the other at the Norfolk Navy Yard at Portsmouth, Va. All three are being built by the Bureau of Yards and Docks, United States Navy Department, and each is expected to cost 10,000,000 dols. The sill of the dock at Norfolk will be 45·7 ft., and those at Philadelphia, 33·8 ft. below low-water level. Instead of launching battleships from inclined ways, which is increasingly difficult as these vessels become heavier, it appears that the United States Navy Department's largest ships will be built in these large dry docks and floated out; an interesting reversion to a regular British practice of half-a-century ago. The high overhead gantries customary on large building berths can be eliminated by this means. Each of the new dry docks will be spanned by a travelling crane with two 75-ton hooks. In addition, at Philadelphia, where the two dry docks are being built side by side, twelve 20-ton track gantry cranes and three 75-ton revolving cranes will travel along the sides of the docks.

The United States construction total for 1941 is expected to exceed 11,000 million dols., and will, therefore, be larger than ever before, as neither 1928 nor 1929, the previous record years, greatly exceeded 10,000 million dols. There is every indication that defence construction expenditures will continue unabated throughout 1942. The month-by-month schedule of the Office of Production Management, which is the Federal body in charge of the United States defence programme, already averages 1,125 million dols. for 1942. The usual accumulation of private and public non-defence construction can be expected to raise the 1942 volume to 10,000 million dols. For 15 to 18 months more, therefore, the construction industry in the United States must work at top speed; then the war effort will begin to taper off, and it is this period that is now receiving a great deal of attention from industry and the Government generally. It is significant that no post-war plan, whoever may have formulated it, fails to emphasise the need for a high degree of construction activity, especially in public works and slum clearance.

Although Canadian war production will not reach its peak until some time after March, 1942, the output of non-essential civilian items, such as automobiles, washing machines, and radio sets, continues to be greatly reduced, principally to conserve metals. The non-essential use of aluminium has been cut to 2 per cent. of the total production, compared with 27 per cent. last year; the use of nickel has been cut from 40 per cent. to 15 per cent., and zinc, of which 64 per cent. was used last year in consumer goods, will be limited to 25 per cent. Factories and labour are affected very little by these developments. Where normal production has been cut, the Government has awarded defence contracts which in some cases more than make up for the work lost. Plants generally are notified in good time, so that equipment can be prepared and men trained for the new war work. Restrictions on the use of steel, 25 per cent. of which Canada must import from the United States, are becoming more rigid. In effect, Canada is being treated as another State in the United States, and plants are classified in a priority system in the same manner as United States plants. Factories in both countries obtain machine tools, steel and other materials in a similar manner. Despite low water conditions in some parts of industrial Quebec, no power shortage is expected this winter in Canada, though the war industries could use more power if it were available. Generally, however, the expansion of power facilities has kept pace with the pressing needs brought about by industrial expansion. One of the biggest new power sources is the 750,000-h.p. plant in the Lake St. John's area, while additional facilities at Beauharnois, on the St. Lawrence, have been rapidly completed.

On October 1, Major-General Eugene Reybold took over the office of Chief of Engineers, United States Army. He succeeds Major-General Julian L. Schley, who completed a four-year term in that office and has retired from active duty. General Reybold takes over command after a long engineering and military career that followed his graduation in civil engineering from the University of Delaware in 1903. After five years of work as a civilian engineer with the United States Engineer Department on river and harbour work, he received a commission as second lieutenant in the Coast Artillery in 1909. He was promoted to lieutenant-colonel in 1926, when he transferred to the Corps of Engineers. His previous work had included construction duties with the Quartermaster Corps, interspersed with attendance and instructorship in the various schools of the United States Army. In 1927, General Reybold was transferred to the Buffalo, New York, district to act as assistant to the district engineer, and was made district engineer at Sandusky, Ohio, in 1929, to serve on the several engineering boards studying the St. Lawrence River project during the next few years. After a year in Washington, D.C., with the Board of Engineers, he acted as district engineer at Wilmington, North Carolina, and then at Memphis, Tennessee, on Mississippi River control work. In the spring of 1937 he directed the flood defence operations on the Mississippi River from Cairo, Illinois, to the mouth of the Arkansas River. These operations were successful in controlling the record Mississippi River flood of that period. From 1937 until his recent appointment, he served as division engineer, with headquarters at Little Rock, Arkansas. On this work he directed the extensive flood-control programme on the Arkansas, White and Red Rivers. General Reybold is the first Chief of Engineers who has not graduated at the United States Military Academy. Major-General Schley, who graduated at the Military Academy in 1903, has served continuously in the Corps of Engineers, beginning his duty in the Philippine Islands. He was attached to the Military Academy as instructor for several years, and his first position as district engineer was at New Orleans, Louisiana, from 1913 to 1916. He served as district engineer at Memphis, Tennessee, and at Galveston, Texas, dealing with studies and recommendations for Mississippi River flood-control work. From 1928 to 1932, he was maintenance engineer on the Panama Canal and served as Governor of the Panama Canal during the following four years. Before becoming Chief of Engineers in 1937, General Schley had been in command of the Engineering School of the United States Army.

Between July 1, 1940, and September 15, 1941, the United States Navy placed orders for 2,381 vessels, costing over 7,235 million dols. Included among the ships ordered are 17 battleships, 12 aircraft carriers, 74 submarines, and 197 destroyers. The smallest craft in the list is a harbour tug, 65 ft. long. The 2,381 vessels do not include the smaller boats and other items being supplied to Great Britain under the Lease-Lend programme. In the first eight months of 1941, a total of 213 naval vessels of all classes were completed. Participating in this naval expansion are nine United States Navy Yards and 110 private yards. In all, the ships will represent a total tonnage of 2,222,460.

South African Iron and Steel Industrial Corporation.—News has been received from South Africa that the South African Iron and Steel Industrial Corporation, which is carrying out extensions at its Pretoria Steelworks, has now decided to erect an entirely new installation. Work has been commenced on the new steelworks, which will take some four or five years to complete. We understand that the plant will include four blast furnaces each having a daily output of between 750 tons and 800 tons; seven batteries of coke-ovens, each capable of coking 600 tons to 700 tons of coal a day, and Bessemer converters, open-hearth furnaces and rolling mills.

TWENTY-FIVE YEARS OF SHIPPING AND SHIPBUILDING.*

By W. A. Woodeson.

I propose to draw a few comparisons between conditions existing to-day and those of twenty-five years ago, for there is often a great deal to learn by putting side by side corresponding pictures of to-day and of preceding periods. The figures which were published in 1916 of shipping losses during 1915 were considered very serious indeed at the time, but appear light to-day, being less than half of those in 1940. From figures available, the losses in tonnage during 1940 were more than double that of the new tonnage launched during the same period from British shipyards. It must be borne in mind that the output of tonnage in Britain prior to the 1914 war had been, for quite a period, about 60 per cent. of the world output. Prior to this war, our output varied to about 35 per cent. of the world output.

The part played by American shipyards in the early years of the last war represented less than 1½ million tons per annum, but by the end of the 1914-18 war the rate of production was approximately 3,000,000 tons per annum. To-day, the United States are being called upon to extend their output again. This time more circumspection has attended the planning of the operation. We are looking forward to a more economic product, in time to be of vital service in replacing lost tonnage. We must advocate the construction of shipping both in America and this country to the greatest possible extent, but we must not forget our experience at the end of the last war. We had an enormous amount of shipping, and if the same conditions prevail again it will be most essential that the Government should act in some very forcible and drastic manner to prevent the post-war tragedy experienced on the previous occasion.

Sir Archibald Hurd, last year, warned us that, unless our shipping losses were going to increase, the shipping of the United Kingdom would be considerably greater than at the beginning of the war. The Ministry of Shipping, therefore, will have no mean fleet of new cargo ships in its possession, and however wisely the war plans may be laid, unless the Admiralty and the Ministry of Shipping act drastically and rapidly the industry will probably face another post-war crisis. Sir Archibald Hurd also pointed out that the arrears in liner construction, which were heavy before the war, will have increased, and the shipping companies, confronted with more intense and more uneconomic competition than in the past, will not be in a position to place contracts. Shipping having been controlled from the beginning of the war, owners have had no opportunity to create large reserves on which to draw for replacement purposes. Therefore, in such circumstances, a post-war slump in merchant shipping is almost inevitable, unless strong precautionary measures are adopted.

Consideration of the years 1916 to 1941 would not be complete without a reference to the successful attempt at rationalisation made in the past 14 to 18 years. Between 1916 and 1920 there was a considerable increase in the number of yards in commission, but by 1938, largely due to the activities of the National Shipbuilders Security, Limited, made necessary by the recurring slumps, the number of shipbuilding yards had been considerably reduced. These facts are interesting, particularly when they are considered in conjunction with the present shortage of tonnage and the scramble on both sides of the Atlantic to get new yards into production. Perhaps the experience we have had, and are having, will be sufficient to keep awake the policy I have advocated for many years, and will increase the realisation that this country's very life depends upon ships. Necessary encouragement must be forthcoming from the Government and other authorities to ensure a state of adequate production and employment of new tonnage in the future. At the beginning of the war the British Shipping (Assistance) Bill (1939), which had passed its second reading, was abandoned. It proposed by loans, grants and subsidies to stabilise the two complementary industries of shipping and shipbuilding. These industries are now rigidly controlled and a crucial situation will no doubt arise with peace.

While I have no intention of expressing any opinion on ship design, I would like to ask if any conclusions can be drawn from comparison between the ships of the last war and those of this war. Modifications in design of hull form which have taken place during the last 25 years are not revolutionary and they are not immediately obvious. Great benefit has no doubt been derived from the experience of these years, and particularly from wider use of the experiment model tank. Modifications have been multiplied to improve the efficiency of rudders and the streamlining of stern posts, etc., and considerable progress has been made in propeller design. The cavitation of propellers is a scientific problem which has been shown to be more related to design than to material.

More modified types of cargo ships for specific purposes, with an increasing speed and tonnage, are gradually replacing the cheaper general vessel. Due to the primary requirements of the Admiralty, the urgency of speed of production, and shortage of material and skilled labour, the natural evolution of ship design was rudely interrupted in 1916. Expediency produced the loosely termed "standard ship" of which perhaps the concrete ship was the most remarkable and lamentable example. There were some who felt that the advent of the "standard ship" was a move in the right direction. It was appreciated by all that the variety of duties was too great for complete standardisation, and the development of as much uniformity within the limits of a minimum number of types was felt to be beneficial. The building programme in the United States will, we hope, demonstrate such a modified standardisation.

Modifications to the technique of shipbuilding and allied industries which have taken place in the past 25 years are eclipsed by the attention given to the use of welding. This development is fundamental, in that it affects, or should affect, the design of the product. Riveting is still the major means of construction in this country, but gradually the saving in weight and material due to welding is becoming more recognised. The survey of the effect of welding on the fighting qualities of ships will be one of the most interesting post-war considerations of naval architects, especially in view of the mixed performance of the German capital ships, the construction of which depended so largely on electric-arc welding.

A certain American shipbuilding concern has laid down a yard and shops expressly equipped to produce nothing but all-welded vessels. This company, I believe, has something like 26 merchant vessels of an important type on order, ships of considerable size and capacity. The same yard in June of this year launched an all-welded steamship. This vessel has a displacement of 17,000 tons and is claimed to be the first all-welded passenger-ship built in the world. I think due note should be taken of this considerable development, because a great deal has been said and written on the technicalities for and against this method of construction. Here in 1941 we have an experiment on a most lavish scale. The results obtained by the American vessels should shorten discussions on the part that welding can play in shipbuilding in the future.

One of the most interesting features characterising the period between the two wars has been the parallel development of Diesel and steam propulsion. The advance of the Diesel engine coincided with the growth of shipbuilding activities abroad. Diesel-engine manufacturers in the Scandinavian countries and on the Continent were in advance, for a while, of our activities here. The Diesel ship was largely an experiment in 1916; to-day a very impressive proportion of new tonnage is driven by the internal-combustion engine. Steam, however, has made commensurate progress; these 25 years have seen the full reaping of the benefits of the steam turbine. Whereas, in 1916, 1·4 lb. of coal per shaft horse-power was considered good consumption, to-day a high-class turbine ship only requires between 0·6 lb. and 0·8 lb. of coal per shaft horse-power hour. Gearing faults, during 1920 and 1930, were tackled on a rational basis and are nearly eliminated. The steam reciprocating engine still holds an important place among the prime movers of ships, and the combined reciprocating engine and turbine has also demanded some attention. The chief factors which have emerged from 25 years struggle between the various propelling systems are the thermodynamic economy of the oil engine, the fuel versatility of the turbine, and the low capital cost of the reciprocating engine. These factors must still be balanced according to the specific and peculiar circumstances surrounding each case. I consider it fortunate that no system has had a preponderous advantage. Competition has been healthy; it has not killed or wiped out any of the competitors, but has given all a new lease of life.

In 1916 it was becoming obvious that acute rivalry would soon develop between coal and heavy oil as the prime source of energy for ship propulsion. It will be seen from the figures of world tonnage in Lloyd's Register that the proportion of tonnage using oil has increased from 4 per cent. to 54 per cent. between 1915 and 1940. Internal-combustion engined vessels have increased from 234,287 tons to 16,700,000 tons, whereas steam-driven ships burning oil as fuel have increased from 1,310,000 tons to 20,600,000 tons. This makes a total increase of tonnage using oil from 1,545,000 tons to 37,300,000 tons. During the same period the total tonnage using coal has been reduced from 44,000,000 tons to 31,000,000 tons. Another very significant feature is that the tonnage of tankers on the Register has increased from 1½ million tons in 1914-1915 to 11½ million tons in 1939-40.

There is no doubt that, in existing circumstances, high-powered vessels on regular routes with uniform bunkering facilities should be fuelled with oil. At many points on the world's seaboard, however, and particularly on our own coasts, the immediately accessible fuel is coal. The greater proportion of the world's tonnage would benefit from the ability to bunker either oil or coal at will. I believe this plain fact will again emerge into importance, and pulverised coal will find its place as an alternative fuel with oil in dual-purpose burners.

The water-tube boiler is closely associated with the progress made. Steam temperatures and pressures have been more than doubled in the past 25 years for marine purposes, and pressures of 500 lb. per square inch, and temperatures of 800 deg. F., have been fairly common. The size of individual boiler units has also increased, with a corresponding reduction in the number of boilers. Not a little of the success attained with large units working under high pressures has been the result of the solution of the problem of condenser-tube corrosion. There have been numerous designs of water-tube boilers, which have attracted some attention, and there has been some work done with the mercury-vapour boiler. The most extensive progress, however, has been made with the plain, well-designed, three-drum boiler, which perhaps has shown more usefulness than other types, especially where a very large steam capacity has been required from a small space and a small weight. One or two types of two-drum boilers have also been developed which can claim similar advantages. Mechanical stoking has met with limited success. The undoubted gain of efficiency over hand-firing, however, has been clearly demonstrated in several cases.

The use of electricity on ship-board has made considerable progress. Electric motive power has been used for main propelling machinery, but the real progress, up to now, is particularly in auxiliary machinery. An outstanding development has been in the electrification of deck machinery, which still has a higher first cost than steam machinery, but, by virtue of its reliability, has proved to be much less expensive than previously. This applies particularly to the electric cargo winch.

* Presidential address to the North-East Coast Institution of Engineers and Shipbuilders, delivered in Newcastle-upon-Tyne on Friday, October 17, 1941. Abridged.

THE COLLISION AT DOLPHIN JUNCTION, G.W.R.

At about 2.55 a.m. on July 2, a collision occurred at Dolphin Junction, between Slough and Langley stations on the Great Western Railway. The trains involved were the 6.20 p.m. up passenger train from Plymouth to Paddington and the 1.30 a.m. down goods train from Old Oak Common to Severn Tunnel Junction. Five passengers were killed; five others, and the driver of the goods train, received serious injuries; and 19 other persons, including the remaining three enginemen and the guard of the goods train, were slightly injured or suffered from shock. An inquiry into the circumstances and cause of the accident was subsequently held by Major G. R. S. Wilson, R.E., whose report has now been presented to the Director-General of the Ministry of War Transport. In accordance with war-time practice, the report is not being printed and published in the usual manner, but we have received a copy from the Ministry, from which the following summary has been prepared.

The passenger train comprised eight bogie corridor coaches, weighing 239 tons, and was hauled by a 4-6-0 locomotive, No. 4091, of the Great Western Railway Company's "Castle" class, weighing 126½ tons with the tender. The combined weight, therefore, was 365½ tons. The total length of the train was 188 yards. All the coaches were of modern construction, with heavy steel underframes and bodies of steel panelling on wood frames. The goods train consisted of 62 wagons, unbraked and loose-coupled, and a 20-ton brake van, and was drawn by a London Midland and Scottish Railway engine, No. 8293, of the 2-8-0 type; one of 25 locomotives lent by the L.M.S. Railway to the Great Western Railway towards the end of 1940. It was fitted with the steam brake on the coupled and tender wheels, but was not equipped with the G.W.R. automatic train control apparatus. About a third of the goods wagons were empty, and the weight behind the engine was approximately 630 tons. The total weight of engine and train was about 757 tons, and the braking power, about 10 per cent. of that amount. The overall length of the goods train was about 433 yards.

Dolphin Junction is approximately midway between Langley and Slough stations, and some 17½ miles from Paddington. It is an important regulating signal box, at which frequent diversions are made between the main and the relief lines, and to an up goods running loop. When trains are running out of course, the

signalman is permitted to exercise his discretion as to routing. The lines run east (up) and west (down), and the order of the four principal tracks, from north to south is up relief, down relief, up main and down main. At the junction there are two pairs of facing cross-overs, close together, the eastern pair being left-handed (up main to up relief and down relief to down main) and the western pair, right-handed (up relief to up main, and down main to down relief). The accident took place at the eastern cross-overs. There are no track circuits. East of the box, the line is straight for 1,100 yards, but a bridge limits the signalman's view to about 800 yards; and from the centre of the box, it is only about 600 yards. The driver's position on the L.M.S. engine was on the left-hand side (contrary to Great Western Railway practice) but the driver was familiar with the engine and stated that this did not incommode him.

The Plymouth train, running about 32 minutes late, was overtaking a goods train carrying Government stores, on the up main line, and Signalman Welch, at Dolphin Junction Box, was considering diverting it to the up relief line. He accepted the 1.30 a.m. goods train from Langley, he stated, after being notified from Slough East that the Plymouth train had left Reading. The Government stores train passed Dolphin Junction at 2.49 a.m. Welch returned "Train out of section" to Slough East and was then offered the Plymouth train, which he accepted, while keeping his up main-line signals at "Danger" behind the Government stores train. Welch's account, at this point, was confused. He stated that he began to inquire whether the up relief line was clear, then obtained "Line clear" on the up main for the Plymouth train; but he cancelled this, and got the train accepted on the up relief. He then set the junction from the up main to the up relief line, although he knew that the 1.30 a.m. goods train was approaching, having accepted it from Langley. He said that he watched the headlights of this train, and judged that it had stopped at the down-relief line home signal; but it had not done so, as the driver had seen the signal against him at a range of only 300 yards to 400 yards and did not succeed in pulling up in time.

Major Wilson, in stating his conclusions, considered that the Plymouth train was travelling at about 19 m.p.h. over the crossing (a figure confirmed by tests) and that the goods train was making between 15 m.p.h. and 20 m.p.h. at the moment of collision. In the 80 seconds that the Plymouth train would require to reach the crossing, the goods train would have covered about 506 yards, assuming its initial speed to have been the normal one, in that section, of about 30 m.p.h. This indicated that, when Signalman Welch reversed the cross-over for the Plymouth train, the goods train must have been at least 1,074 yards from the Dolphin Junction Box, and could not have been in sight from Welch's position inside the box. His suggestion, therefore, that he had committed an error of judgment in assuming that the goods train had stopped, Major Wilson considered to be "clearly false"; the evidence was convincing that he had made no attempt to satisfy himself that this was the case. It must be concluded that Welch, in his anxiety to avoid further delay to the Plymouth train, set the junction and lowered the signals for it while assuming, without justification, that the goods train would stop at the home signal. This was in direct contravention of the G.W.R. Company's block regulation (No. 4 (c)), laying down the conditions which must be observed to constitute "Line clear." This clause states that, after permission has been given for a train to approach, in accordance with regulation 4, "no obstruction of the line on which such train requires to run must be allowed within a distance of a quarter of a mile ahead of the home signal or other prescribed clearing point, neither must any points to the rear of the authorised clearing point be altered," except where special instructions to the contrary are in force. The signal at which the goods train failed to stop was only 161 yards from the box and 93 yards from the point of collision. Major Wilson expressed inability to find any excuse for Welch's failure, and the opinion that, in spite of his good record, he was temperamentally unfitted for the duties of a signalman in a busy main-line junction box. The confusion of his mind which apparently resulted from the realisation of a comparatively trivial mistake (in not diverting the Government stores train to the up relief line, so leaving the main line clear for the Plymouth train) led him into a complete disregard of safety.

MACHINE-TOOL MANUFACTURE IN INDIA.—Many of the machine tools required in connection with work in the Ordnance Factories of India have to be imported. Some, however, including lathes, and drilling, shaping, planing, slotting and hacksawing machines, are now being made in India, and 54 firms are licensed to manufacture machine tools under the Machine-Tool Control.

LABOUR NOTES.

IT has already been mentioned in these columns that in the industries for which statistics are regularly compiled by the Ministry of Labour and National Service the changes in rates of wages reported to have come into operation in September resulted in an aggregate increase estimated at about 39,000*l.* in the weekly full-time wages of about 238,000 workpeople, and in a decrease estimated at about 1,500*l.* in those of 76,000 workpeople. The employees, whose rates of wages were reduced, had received increases of greater amount during earlier months. Of the estimated total increase of 39,000*l.* a week, about 200*l.* was due to the operation of sliding scales based on fluctuations in the proceeds of the coal-mining industries, 31,500*l.* to arrangements made by joint standing bodies, and 400*l.* to the operation of sliding scales based on the cost of living. The remaining 6,900*l.* was the result of direct negotiations between employers and workpeople or their representatives. Nearly all of the estimated decrease of 1,500*l.* was due to the operation of sliding scales based on fluctuations in the proceeds of the coal-mining industry.

The changes reported in the first nine months of 1941, in the industries covered by the statistics, are estimated to have resulted in a net increase of about 1,500,000*l.* a week in the full-time wages of over 7,500,000 workpeople. In the corresponding nine months of 1940 there was in these industries a net increase estimated at about 1,750,000*l.* in the weekly full-time wages of approximately 7,700,000 workpeople. The particulars of numbers affected and amounts of wage changes exclude changes affecting Government employees, agricultural labourers, and shop assistants and clerks for which classes the information available is not sufficient to form a basis for statistics.

The number of trade disputes involving stoppages of work, reported to the Ministry of Labour and National Service as beginning in September, was 135. In addition, 13 disputes which began before September were still in progress at the beginning of that month. The approximate number of workpeople involved in these 148 disputes (including workpeople thrown out of work at the establishments where the disputes occurred) was 31,000 and the aggregate duration of the disputes in September was about 93,000 working days. The great majority of the disputes involved less than 100 workpeople, and about two-thirds of them lasted for not more than three days.

The Central Agricultural Wages Board decided last week to recommend that the national minimum wage should be raised from 48*s.* to 56*s.* a week. The proposal will go before the county committees, and their representations will be received by the Central Board on November 18 when the operative decision will be taken. A claim for a national minimum of 3*l.* a week was submitted by the unions in the early summer, and, when the Board decided to defer its decision on it, the independent members added their opinion that, after the harvest, some increase might be possible and proper. The reconsideration has resulted in the concession of 8*s.* a week instead of the 12*s.* a week asked for. It is, of course, an increase of the minimum wage and necessarily will only apply to the full extent in counties where the national minimum is also the county minimum. Elsewhere, the adjustment of county wage rates will be subject to local negotiations.

Interviewed on his return from Russia with the Trades Union Congress delegation, Sir Walter Citrine said that at Kuibishev they visited two arms factories and found them employing 65 per cent. and 75 per cent. of women, respectively—and all the workers labouring enthusiastically 66 hours a week with one day off in seven. The output had increased by as much as 460 per cent. over the pre-war level.

An award made by the Industrial Court last week fixes the charge pay for chargemen of skilled labourers in Royal Dockyards and other Admiralty establishments at 12*s.* a week rising to 21*s.* according to the number of years of service. The Chargemen's Association had asked for a scale varying from 13*s.* to 22*s.* a week and the Trade Union side of the Shipbuilding Trade Joint Council for Government Departments, for one varying from 15*s.* to 24*s.* The award became operative last week.

At the closing session of the International Labour Organisation's conference in New York, it is reported, representatives of the American Federation of Labour and the Congress of Industrial Organisation so far forgot their differences as to join in proposing a resolution, which was adopted, urging that responsible representatives of the employees and the employers should be included in public agencies concerned with planning and applying public policies directly or indirectly affecting the interests of the workpeople and the employers.

An agreement increasing the wages of women engaged on war work in engineering factories was reached at a conference in London, on Thursday last week, between representatives of the Engineering and Allied Employers' National Federation and representatives of the Transport and General Workers' Union and the National Union of General and Municipal Workers. Women over 21 years of age are to receive an addition of 5*s.* a week, bringing the basic rate up to 25*s.* and the total weekly wage up to 43*s.* Women 20 years of age are to receive an addition of 4*s.* 4*d.* to the basic rate, bringing the total weekly wage up to 41*s.* a week, women 19 years of age 3*s.* 8*d.*, bringing the total weekly wage up to 39*s.*, and women 18 years of age 3*s.*, bringing the total weekly wage up to 37*s.* a week. The new rates are to operate as from November 16. The unions had asked for an advance of 9*s.* a week.

The National Arbitration Tribunal has rejected a claim for increases of wages for boys and youths under the age of 21 (other than apprentices) members of the Transport and General Workers' Union and the National Union of General and Municipal Workers who are employed in the engineering industry. Claims for increases of wages for silversmiths have also been rejected.

Under an agreement to which the Newspaper Society, the British Federation of Master Printers and the Printing and Kindred Trades Federation are parties, men, and also women doing men's work, are to receive a further addition to their bonus of 5*s.* a week. Women are to receive a bonus of 3*s.* 6*d.* a week and male and female juveniles and apprentices one of 2*s.* a week. The new rates will be payable also in Scotland, and it is expected that in due course, they will be extended to the staffs of London newspapers published in Manchester and Glasgow.

As industry is short of electric welders, the age of reservation in the occupation of electric welder (general hand) has been reduced from 23 to 21 in protected establishments. Elsewhere the age is 35.

Many men—probably over 40,000—under 25 years of age, whose call-up for military service is at present deferred, are prospectively affected by a decision of the Minister of Labour and National Service announced last week. Deferment has up till now been granted in the case of these men because they were in "key" positions or on grounds of special hardship. It has now been decided that, except for men in certain essential occupations, no further deferments are to be granted to men who, on registering, were under the age of 25, and current deferments in respect of such men are to be cancelled.

The "comb-out" is to be carried out in two stages. On December 1 it will affect men of 19 at date of registration who are in occupations reserved at 21, men of 19 and 20 where reservation is at 23, and men of 19 to 21 where the reservation age is 25 and over. On January 1, 1940, the remainder of the men to be dealt with will have their deferments cancelled. Their employers will be informed of men who are affected by the change. No information is given of the occupations which are to be excepted, but it is understood that those which are covered by special schemes such as the agricultural and coal-mining industries, remain affected.

Under regulations issued by the Controller of Industrial Man Power in South Africa the engagement, by employers in the engineering industry, of emergency labour is prohibited without the prior consent of the competent industrial council. Emergency labour is defined as "any untrained or partly-trained labour employed during the war period additional to, or as a substitute for, skilled labour," and consent to the employment of such labour may be granted only to employers engaged on defence work or work which is essential for the purposes of the mining industry or the Railways and Harbours Administration or to other employers if the labour required is to replace journeymen transferred by the Controller. Such workers have to be provided with registration cards which are retained by their employers during the period of employment.

LIQUID PITCH FUEL.*

By E. Brett Davies.

To the *Journal* of the Institute of Fuel for April, 1939, the writer contributed a paper on the use of pitch as a fuel. The closing remarks of that paper state: "Attention should be drawn to the inherent value of a home-produced fuel which can in many cases be used as a substitute for imported fuel oil. The fact that such a fuel is available in the event of international difficulties should add impetus to the study of this new branch of fuel technology." The time of international difficulties is now upon us, and the optimum use of our indigenous materials is of great importance. Before proceeding to technical details of recent progress, it is perhaps advisable to make three general statements, viz.: The liquid fuel consumer is aware that the Petroleum Pool Board are authorised by Government order to be the vendors of all liquid fuels within certain limits of viscosity. It is not the purpose of this paper to discuss technicalities as applied to these "pool" fuels, although the reader may at times be able to draw parallels. While, in April, 1939, the technical development of liquid pitch fuel was at an elementary stage, considerable progress has been made since. In 1939, the opinion was expressed that the fuel was most likely to develop as a pulverised solid fuel, to the general exclusion of liquid medium soft pitch; this has proved incorrect and the reverse is practically the case. Quite a number of pulverised hard pitch consumers have been established, but work during the past year has been for various reasons almost exclusively directed to the use of pitch as a liquid fuel. While technical work has progressed, actual commercial development has been slow, and it is now possible to draw upon stocks of solid pitch for fuel purposes as well as upon the current make.

Physical and Chemical Data.—The purpose of this paper is to deal exclusively with the use of normal medium-soft pitch fuel as burnt in a liquid state. This pitch, which was formerly largely exported to Continental briquetting markets, has a softening point, as determined by the method of Kraemer and Sarnow, of 70 deg. C., a calorific value of 16,250 B.Th.U. per pound, and the following is a typical ultimate analysis of the material:—

	Per cent.		Per cent.
Carbon	90·0	Sulphur ...	0·7
Hydrogen ...	5·4	Nitrogen ...	1·4
Oxygen (diff.) ...	2·3	Ash	0·2

Pitch contains no inherent moisture, and being neither porous nor absorbent, superficial moisture, save in exceptional circumstances, is negligible. Since the development of liquid pitch firing, a correct figure for specific heat has become most important in regard to melting and heat-transfer problems. For purposes of calculation a safe figure of 0·4 may be taken, although in the writer's experience a figure of about 0·34 appears to be more correct. This figure may appear to be on the low side, but it is probably accounted for by the fact that pitch contains free carbon in quantities up to 25 per cent., and the specific heat of carbon is of the order of 0·24. The existence of any latent heat of fusion of pitch has not been detected in pitch-melting experience, and this characteristic, for practical purposes, may safely be ignored. This phenomenon is to be expected since pitch is never at any time a true solid in the physical sense and has a viscosity even at atmospheric temperatures, when it handles as, and appears to be, a solid.†

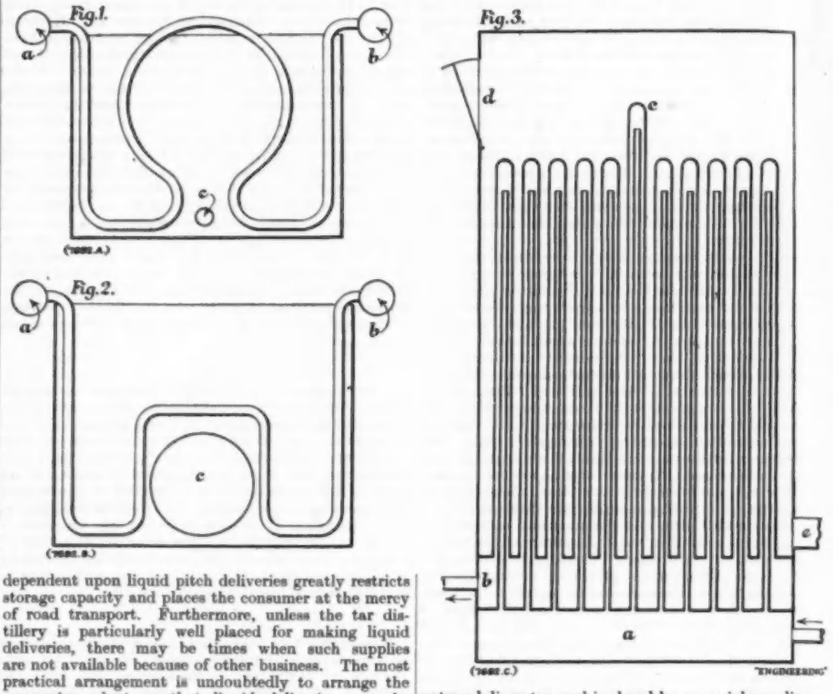
Transport.—The transport of medium-soft pitch in lump form presents no problems other than those experienced in the handling of other bulk solid fuels such as coal. In warm weather it is possible that the pressure faces between fragments of pitch may adhere, but in such circumstances the insertion of a lever in the interstices is sufficient to cause the masses to break apart. During nine months of the year lump pitch handles precisely the same as screened coal, and it is only during the summer months, and then during particularly warm weather, that the tendency to adhere becomes noticeable. In several instances pitch fuel is transported as a hot liquid in insulated tank wagons. Due to the general excellence of modern heat insulation, a suitably lagged 5-ton tank load of pitch when loaded at 200 deg. C. will not lose more than 2 deg. per hour and will thus remain suitable for pumping for at least 24 hours. In arranging pitch fuel supplies it is advisable to examine the possibility of liquid deliveries since, if these are feasible, "getting" costs are obviated at the tar distillery and melting costs at the consumer's works are reduced to much less expensive heat boosting arrangements. On the other hand, to be entirely dependent upon liquid pitch deliveries greatly restricts storage capacity and places the consumer at the mercy of road transport. Furthermore, unless the tar distillery is particularly well placed for making liquid deliveries, there may be times when such supplies are not available because of other business. The most practical arrangement is undoubtedly to arrange the consuming plant so that liquid deliveries may be received, but to include melting facilities for stand-by, make-up, and similar contingencies.

Pitch Melting.—At a works where steam is available at an adequate pressure, this medium forms the most convenient means of pitch melting. The optimum temperature for the atomisation of pitch for combustion is 200 deg. C. (392 deg. F.), and since steam temperature varies with pressure and steam may not be available at pressures equivalent to 200 deg. C., boosting of temperature, either by electrical or other methods after melting by steam, will usually be found necessary. With regard to the actual design of the steam-tube melter, this largely depends on individual preference and the materials at hand. Figs. 1 and 2 show simple shapes of tube element mounted in a rectangular tank. The number of elements depends upon the capacity of the melter. They are set in the form of a close grid upon which the pitch melts and through which the pitch must flow to reach the outlet. It would be advisable with this construction to brace the loops across the neck to prevent side thrust. If this melter is used as a circulating tank, the pitch return should be brought within the loop at the end of the tank opposite to the outlet. The steam inlet is seen at *a*, in both figures, and the steam outlet, connected to a trap, at *b*. The circle marked *c* in Fig. 1 is the pitch outlet, and in Fig. 2, represents a cylindrical outflow heater, electrically operated and thermostatically controlled at 200 deg. C. Both types of melter are simply constructed, and since the elements may be lifted out of the tank in one piece, cleaning-out operations are simplified. It will be noticed that in each case the hot elements break the pitch surface; this is a good point, and prevents frothing due to moisture if the solid fuel is handled in wet weather. A cylindrical thimble-tube melter which has proved satisfactory in service is shown in Fig. 3. Steam enters the chest *a* and passes upwards through small-bore tubes, expands in the thimble tubes, discharging into chest *b*, whence it is exhausted through a trap. The long tube *c* breaks the liquid surface to prevent frothing. The solid pitch opening is at *d* and the liquid pitch outlet at *e*. In general, melters should be constructed and tubes spaced so that it is not possible for the pitch in either a solid or a plastic state to short circuit the heating element and pass to the outlet, thereby causing blockages. All melters should be adequately lagged, and all tubes submerged in pitch should have welded joints.

As an alternative to using works steam, the type of closed-coil steam melter shown in Fig. 4, opposite, may be used. This melter consists of a melting tank *a*, which is thoroughly insulated against heat losses and contains a bank of steel tube loops *b*. Each of these loops is made from special section steel tubing $\frac{11}{16}$ in. in external diameter, and is closed by a special coupling *c*. Before closing, each loop is partially filled with water, and tested to withstand a pressure of 5 tons per square inch. Each loop forms a self-contained boiler and steam circuit and is graded to its lowest point which passes through the furnace *d*, which may be fired with coke or any other convenient fuel. Pressure gauges are mounted on a number of the loops and may be calibrated to indicate temperature. A normal working pressure when melting pitch is 1,500 lb. per square inch. In order to ensure effective circulation within these loops, a cold leg *e* is provided which is exposed to atmosphere. Unless it is desired to work this plant at a high capacity, it would be unnecessary in most instances to use further heat boosting, since an outlet temperature of 200 deg. C. is quite within the range of the apparatus. The outstanding advantage of this type of melter is its complete portability, and provided that a supply of fuel for heating the tube furnace is available, the melter is independent of other works services.

A third type of melter which has been employed quite successfully is that which uses the circulation of hot oil through coils contained in a melting tank as a means of heat transfer. The oil, which is a special grade of mineral oil capable of withstanding high temperatures without cracking, is heated in a small boiler arrangement fired preferably with liquid fuel or gas in order that the fuel consumption may be thermostatically controlled. The hot oil is circulated through the melter coils by pump and can also be used while on circuit for the heating of cocks and the jacketing of pitch-carrying mains. Heat transfer coefficients for this type of melter as high as 20 B.Th.U. per square foot per degree F. per hour have been achieved. The hot-oil melter has the advantage of great controllability and, like the closed-coil melter, it is transportable. Disadvantages are the high initial cost and also the complicated construction.

Before leaving this part of the subect a word should be said regarding electrical melting, as distinct from electrical boosting and heating. Units have been designed having the requisite low wattage to prevent overheating and carbonisation of the pitch. Electrical heating, moreover, is capable of the closest thermostatic control and should, therefore, be admirable for this purpose. Unfortunately, however, electricity as a bulk heating medium is comparatively expensive, and an electrical consumption of the order of 100 units per ton is not always commensurate with the advantages to be gained from the use of electrically melted pitch fuel even if the power lines to the consumer's works are capable of handling the additional load. Nevertheless, the possibilities of electrical melting should not be overlooked when pitch-melting plant is contemplated.



* Paper read before the Institute of Fuel on Thursday October 30, 1941. Abridged.

† The viscosity of M.S. pitch at 60 deg. F. has been published as $1 \cdot 3 \times 10^{10}$ Poises.

LIQUID PITCH FUEL.

Fig. 4.

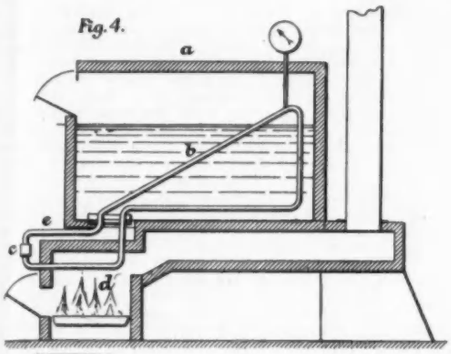


Fig. 5.

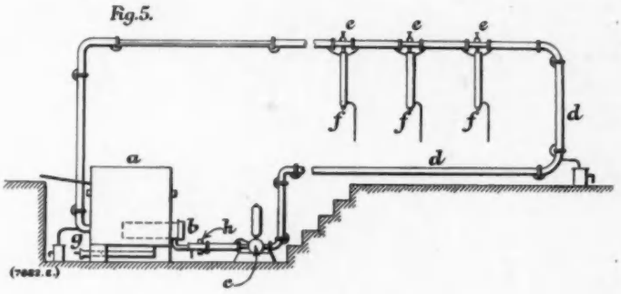


Fig. 6.

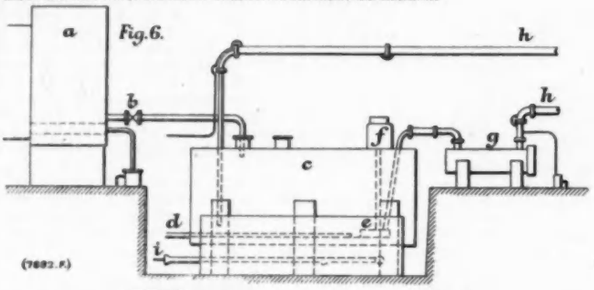


Fig. 7.

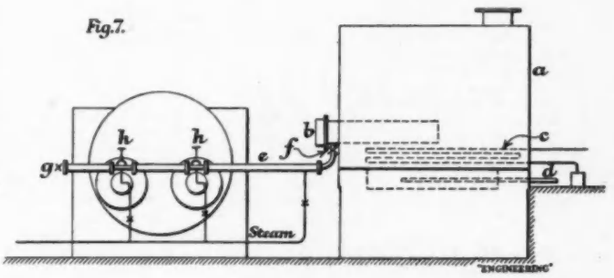


Fig. 8.

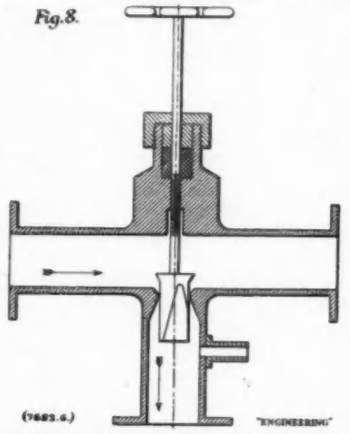
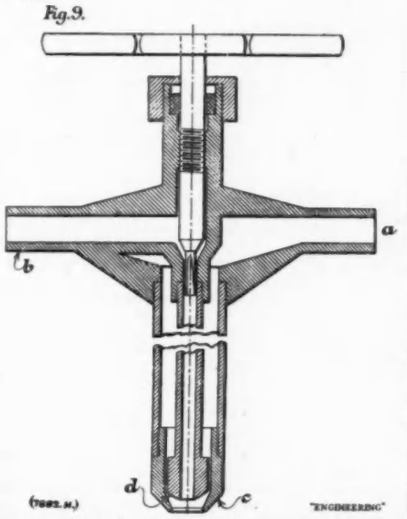


Fig. 9.



Electrical Boosting.—In many instances, either to supplement works steam melters or for topping up the temperature of liquid pitch deliveries, the most convenient type of booster is the electrical flow heater. These heaters are usually thermostatically controlled and several makes are available in all capacities for the purpose of raising the fuel temperature to 200 deg. C. before it passes to the ring main. Heaters should be placed so that they are never empty, and in such a position that the elements can be withdrawn for replacement. A very sound plan is to arrange a small neon lamp indicator to show when the heater is in operation. In various diagrams throughout this paper different dispositions of the flow heater are indicated with the object of illustrating possibilities in this direction. It is not advisable to place a flow heater immediately behind a burner, since this practice is likely to provoke the deposition of free carbon in the burner valve and cause fading and instability.

Storage.—In general, it is not advisable to carry large stocks of liquid pitch at elevated temperatures, *i.e.*, 200 deg. C., and if it is not desired to work a melter continuously as part of the circuit, as is demanded by a flow diagram of the type illustrated in Fig. 5, a system such as that shown in Fig. 6 should be adopted. The equipment shown in Fig. 5 is for a ring main system direct from a melter. The melter, of the steam-tube type illustrated in Fig. 2, and acting as a circulating tank, is indicated at *a*, Fig. 5. There is a thermostatically-controlled electrical heater at *b*, to which is coupled a steam-jacketed ram pump *c*. The ring main is seen at *d*, the portion above the melter being shown with the lagging removed in order to render the steam heating "tracer" pipe visible. The Tee-valves *e* lead to the steam-jacketed burner supply pipes *f*. An emergency gas heater is shown at *g* and a steam-jacketed outlet cock at *h*. The equipment shown in Fig. 6 uses a buffer tank in which pitch stocks are carried at 150 deg. C. with a heater to cover radiation losses. Such a system is admirable for employing melted solid pitch stock in conjunction with liquid deliveries. The melter, of the type shown in Fig. 3, is seen at *a*, with a steam-jacketed control cock *b* and a pipe leading to the buffer tank *c*. Either a steam coil or an electrical heater is situated at *d* and a submerged rotary pump is seen at *e* driven by an external motor at *f*. An electrical flow heater is seen at *g*, parts of the ring main at *h* and an emergency gas heater at *i*. In all cases, this heater should be treated as an emergency, or, at best, a temporary, measure, since, as already noted, the prolonged heating of pitch under static conditions by direct flame may easily lead to coking and unpleasant cleaning out troubles.

Feed Systems.—Having by one means or another liquefied the pitch and raised its temperature to 200 deg. C., it is necessary to consider the various methods of conveying the fuel to the burners. When comparatively few burners are placed in close proximity to the fuel supply, gravity feed lines have been found quite adequate. Fig. 7 depicts this system. The storage tank, receiving either hot liquid deliveries by tank wagon or to be operated in conjunction with a melter, is indicated at *a*. An electrical outflow heater is shown at *b*, a steam coil to balance radiation losses at *c*, and an emergency gas heater at *d*. The pitch main at *e* has a steam-jacketed cock at *f*, and a drain cock at *g*. The Tee-valves to the burners are indicated at *h*. For all other lay-outs the ring main system has been found superior. When using either of these systems, provision must be made for heating up the pitch line prior to passing the fuel, but once having established a free flow, unless the line heating medium is at a temperature higher than the pitch fuel temperature, it is a disadvantage that such "heating" should be continued, and the pitch flow is quite adequate to maintain the temperature. As a method of heating fuel lines, a simple and common practice is to clip a ½-in. steam line in metallic contact with the pitch line and lag the two together.

As an alternative to this "tracer" line method, the pitch line may be steam-jacketed concentrically, but this is expensive and, except for exposed lengths of line, which might be liable to freeze and for short lengths from mains to burners, need not be practised. In one first-class installation the pitch is received into a circulating tank at about 170 deg. C., and is passed through a ring main around a boiler house. The pitch main is concentrically jacketed with steam at 250 lb. pressure, and it is found that the storage tank temperature rises due to the return temperature of the surplus pitch being higher than the outgoing pitch temperature. This is, however, an exceptional instance. If the pitch were received at 200 deg. C. into the storage tank or, alternatively, if the pitch were heated as it left the tank at 200 deg. C. either electrically or by a steam line heater, then the need for maintaining the steam jacket under pressure would be obviated and a small steam coil in the storage tank would cover radiation losses.

With all pitch lines, a line speed of between 30 ft. and 60 ft. per minute should be arranged, and in the case of ring mains at least 2½ times the fuel consumption should be circulated. The pressure of the fuel at the burner should not exceed 15 lb. per square inch. This pressure has no function in so far as atomising at the burner is concerned, and merely ensures a uniform feed. Numerous gravity feed systems are in daily operation which function perfectly well with a pitch fuel head of 4 ft. to 12 ft. A cock is often used at the outlet from pitch storage tanks as a means of turning the supply either fully on or fully off. Such cocks are normal cast-iron plug cocks and are obtainable with a steam jacket as an integral part of the casting. For tapping off from the pitch mains to burners, the Tee type of valve, shown in Fig. 8, is admirable. This valve is ported to permit a solid flow rather than a thin lengthy stream, and it also has the advantage of being directly in the fuel stream and does not readily "make up." Furthermore, the Tee valve, when closed, does not create a pocket in which the pitch could solidify. The horizontal pipe in Fig. 8 is the ring main. The vertical branch leads to the burner and

is fitted with a small steam inlet branch for clearing purposes. Liquid pitch branch pipes and short gravity feed lines may be provided advantageously with a steaming-out connection as shown in Fig. 8. This is particularly useful if the steam is at a high pressure, but if the steam is at a low pressure and wet, then the steaming period must be prolonged sufficiently to ensure that there is adequate residual heat in the line to dry out all water, otherwise, on the addition of hot pitch, frothing and choking may occur.

Pumping.—As a general practice the tar distiller has always handled hot liquid pitch with a steam-jacketed ram pump. For supplying a ring main this type of pump serves quite well and may be placed with a drowned suction, as shown in Fig. 5. It is very necessary when using this type of pump for fuel work that the air-balancing vessel should be used correctly to prevent uneven fuel pressure from causing the flame length to advance and recede in sympathy with the stroke of the pump. On pitch work it is generally found necessary to drain the air-balancing vessel at least once per eight hours. As an alternative, a small steam supply pipe may be connected to the top of the air-balancing vessel and the pump stroke balanced against a pressure of about 15 lb. of steam. This practice frequently works quite well, but care must be exercised, since on a number of occasions the steam has been known to blow out the pitch lines due to excessive steam pressure. An interesting alternative to the ram pump is the rotary gear displacement pump which may be totally submerged in the liquid fuel. This type of pump is usually driven by a small electric motor mounted with its axis vertical on the top of the fuel tank. The arrangement is shown in Fig. 6. As it is totally submerged the pump requires no heating, and leaking glands and lubricating troubles often associated with ram pumps when working on hot pitch are absent.

Burners.—The atomisation of pitch and its injection into the furnace are generally accomplished by a burner of the high-pressure steam type using at least 50 lb. steam pressure as the atomising medium. On occasion, hot compressed air has been used in place of steam, to which it is felt to be superior; but in normal practice, due to the general availability and convenience of steam, this latter medium is most frequently used. The possibility of using as alternatives the pressure-jet atomising system or the low-pressure air system have been discussed from time to time, and while, in the opinion of the writer, the former is definitely ruled out on the score of nozzle carbonisation and the high pitch temperature necessary to achieve the required fluidity, the latter method presents no theoretical difficulties, but has not been adopted, chiefly because of the difficulty of preheating large volumes of air from atmospheric temperature up to 200 deg. C.

The apparent simplicity of the pitch burner has frequently led fuel consumers to design and to manufacture their own burners. Unless this is expertly executed, poor atomisation and high steam consumptions are likely to occur, which may lead to dangerous repercussions. Good oil and liquid-fuel burners are the result of considerable thought and research; and while their refinements and carefully calculated proportions may not be at once evident, the ordinary burner user is well advised to purchase a proprietary burner, even at additional cost, rather than to experiment in making his own. The immediate effect of poor atomisation is that the larger particles have an appreciable kinetic energy, and can therefore travel greater distances within the furnace before they are consumed. With the home-made burner the injector effect of high steam consumption can further aggravate this fault, and excessive flame lengths, lack of stability, and carbon deposition around ports and on furnace walls are generally symptoms of poor burner performance. Large particle size may also tend to widen the flame angle, which in many cases is a disadvantage. A well-designed high-pressure burner should use one part of atomising medium to three parts of fuel. It should be noted that even with a well-designed burner, poor atomisation and its concomitant troubles can occur if the fuel temperature is not high enough to give the low viscosity necessary for atomisation.

Many modern burner sets incorporate a quick release mechanism whereby the burner may be changed in a matter of seconds. This is a very desirable feature, and the practice of carrying a spare burner to permit the burners in commission to be changed and cleaned once per shift is to be recommended. In Fig. 9, page 399, the section of a typical high-pressure burner head and nose is shown. The steam branch *a* and the pitch inlet branch *b* are formed with plain plug ends to engage readily with the quick-release mechanism. The pitch flows through the central tube and the steam through the annular space between it and the outer tube which has a cast-iron nose *c* embracing a cap on the central tube. This cap is formed with grooves on its external periphery to give a spin to the steam. The pitch is controlled by the grooved valve shown, this valve being, from its position, virtually steam-jacketed. The barrel of the burner may be of any length.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

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Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GUNS AND EXPLOSIVES.

536,804. Mortar-Firing Mechanism. Woodhouse and Mitchell, Limited, of Brighouse, and C. W. Harris, of Huddersfield. (4 *Figs.*) August 3, 1939.—The firing mechanism is of the "Slip Rock" type, which dispenses with the bridle usually employed for connecting the hammer with one arm of the main spring and so enables the latter to move the hammer in the striking direction, and then retract it slightly. The mechanism consists of a hammer A pivoted at B in the mortar body, which carries the firing pin D. A main spring F of hairpin form is centred in the body and operates and controls the hammer with which it makes contact at H and K in the safety position (Fig. 1), thereby keeping the hammer just clear of the firing pin. This pin is held by its spring clear of the percussion cap. The upper limb of the spring is in contact with a member M pivoted in the sear O, its upward movement being arrested when the sear

Fig.1.

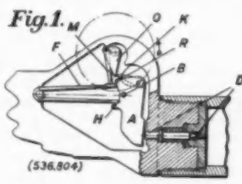

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Fig.2.

comes in contact with a stop, this stop defining the safety position of the parts. A partial anti-clockwise rotation of the sear by the trigger brings it into contact with a pawl R pivoted in the hammer. The pawl turns the hammer in a clockwise direction, further stressing the lower limb of the spring, while the member M further depresses the upper limb and keeps it clear of the inclined face K of the hammer until the instant of release (shown in Fig. 2). As the pawl escapes from contact with the sear, the sear itself is arrested by a stop on the body. After release, the lower limb of the spring, bearing hard on the abutment H of the hammer, uses the hammer to strike the firing pin sharp blows. When the trigger is released, the upper limb of the spring brings the part back to the safety position. (*Accepted May* 28, 1941.)

MOTOR VEHICLES.

537,620. Heavy-Duty Tractor. Scammell Lorries, Limited, of Watford West, O. D. North, of Hunton Bridge, and P. G. Hugh, of Watford West. (3 *Figs.*) January 3, 1940.—The tractor is designed for the transport of such articles as heavy guns, tanks, girders, machinery and

Fig.1.

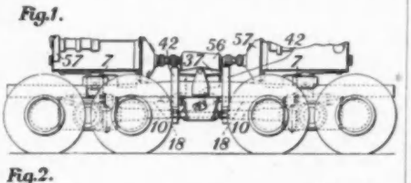
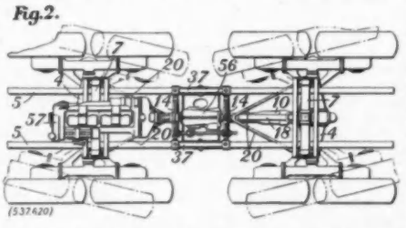


Fig.2.



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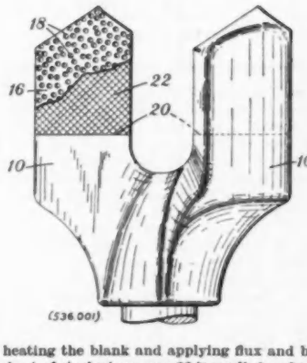
aircraft. Two longitudinal channels 5 constitute the main frame and are suspended by a central stabiliser and two transverse axle housings 4. Balance arms at the ends of the latter carry driving wheels. The axle housings are connected to the main frame by transverse leaf springs. The stabiliser consists of two parallel longitudinal beams 37 immediately above the two main longitudinals 5 at about the centre of gravity of the vehicle, each being mounted on a central pivot pin secured to the main frame. The ends of the two stabilising beams are connected through ball-and-socket joints to front and rear U-shaped links 42, each embracing the adjacent frame longitudinal. The centre of each transverse stabilising arm 14 is attached to the inner end of a torque tube 10, the inner extremity of each torque tube being secured in a ball-housing supported by the frame cross members. The two torque tubes lie fore and aft along the centre line of the vehicle, the outer ends being connected to the pair of axle housings 4. The adjacent ends of the torque tubes are connected by a longitudinal tension bar. Each live axle is driven through a differential gear on the central part of the axle housing, and a propeller shaft 18 from a gearbox 56 at the centre of the frame. The shafts 18 are immediately above and parallel with the torque tubes 10. The torque tubes 10 are pivoted to the inner faces of the differential gear cases on vertical axes to allow for the swivelling of the axle housings. Each axle housing 4 is connected to a spring 7, a short distance from the axis of the axle towards the centre of the vehicle. A stout boss on the axle housing with a central socket receives a ball-head depending from a centre bracket of the transverse spring 7. The ends of the transverse springs 7 are connected by shackles to the main frame 5. The transverse stabilising arms 14 support two transverse worm shafts of the steering mechanism, these two shafts being geared to a longitudinal driving shaft and each carrying a nut. On each nut are pivoted arms 20 secured to the axle housings. The tractor carries two engines 57 mounted over the axle housings and both connected to the common central gearbox 56. The frame is relieved from road stresses and the bogies are free to swivel for steering purposes. (*Accepted June* 30, 1941.)

MISCELLANEOUS.

536,001. Hard-Tipped Tool. Charles Crofton and Company (Engineers), Limited, of Wallsend-on-Tyne, and J. C. Gascoigne, of Newcastle-on-Tyne. (3 *Figs.*) June 29, 1940.—The invention is a method of securing tungsten-carbide tips to the tool body by the process, similar to brazing, which uses the alloy "Sif Bronze," instead of spelter. It is found that this alloy adheres firmly to the tungsten carbide but not so firmly to the steel of the tool body and failure frequently occurs at the bronze-steel interface. Each blade 10 of the rock drill blank shown is formed with a recess for the tungsten carbide tip and the surface 16 to which the tip is to be "brazed" is formed with a large number of small conical depressions 18, made by a centre-punch. The raised rims produced around the depressions must be removed so that the original surface between the depressions remains smooth and continuous. The depressions must be spaced apart so that each of them is isolated. The surfaces 16 and 20 of the recess are now coated with bronze in the usual



(536,001)

way by heating the blank and applying flux and bronze. Next, a sheet of steel wire gauze 22 is applied and secured to the surface 16. Another coating of bronze is added to the exposed surface of the wire gauze and finally the tip is applied and held firmly in position by a clamp. The same operations are carried out on the other blade of the blank. A clamp is used for holding one of the tips in place while the second tip is being applied, and there is no risk of squeezing out the whole of the molten bronze because, even if the steel wire gauze is not used, each small depression 18 is isolated from its neighbours and the small quantities of molten bronze lying in these recesses cannot escape when pressure is applied to the tip. Any that does escape remains as a thin film between the continuous surface 16 and the surface of the tip. The layer of steel wire gauze enhances this effect. The invention is equally applicable to other kinds of tool, such as coal-cutter picks and tools used for turning and boring metals. (*Accepted April* 29, 1941.)